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FRANKLIN INSTITUTE

OF THE STATE OF PENNSYLVANIA,

FOR THE

PROMOTION OF THE MECHANIC ARTS.

VOL. LVI.] JULY, 1868. [No. 1.

EDITORIAL.

ITEMS AND NOVELTIES.

The Hoosac Tunnel.—We have just received the yearly report of the Managing Committee, Engineers, and others concerned in this great work, and find in it many matters of lively interest. In a brief notice of the previous year's report, which we made in this *Journal*, Vol. LIV., p. 9, we related the unfortunate experience which had been encountered in the use of machine drills, and quoted the results obtained, which spoke strongly in favor of the hand application of the tool, both as regards speed and cost. From this, and an article by Prof. De Volson Wood, published in the same volume, p. 83, may be gathered the conclusion reached by the Resident and Consulting Engineers, from a long and thorough trial, namely, that for some reason, rock drilling by machinery, applied with such wonderful success on the Alps, in the Mt. Cenis Tunnel, was with similar machinery a failure on the Hoosac Mountain and Tunnel. This conclusion, though seemingly *demonstrated*

by facts, appeared so extraordinary, that these gentlemen, even while expressing it, could not rest satisfied with such a result, but advised that while in obedience to the commands of experience, the ruinous experiment with machines in the tunnel must be discontinued and hand labor resumed; yet that outside and on an economical scale, efforts should be maintained to improve and strengthen the machinery, so as, if possible, to create something fitted for the work.

Success in this direction was, however, nearer than they had imagined, for, as appears from Prof. Wood's article above mentioned, the adverse report could hardly have been fairly in circulation before improvements were effected in the machines, which completely turned the tables of comparison over to the other side. This timing of the improvement was most unfortunate, as regards the reasoning and advice of the report, which were perfectly sound on the basis of the facts then existing, but of course could have no relation to an absolutely inverted order of things and conditions.

Such an accident or malicious perversity of events, with a young engineer, whose reputation was in the future, might have been serious (thanks to the general tendency to consider that all which goes right is by chance, and all that goes awry is "somebody's fault,") but with Mr. Latrobe, it is simply a good joke, which no doubt his friends have not failed to enjoy. With the improved machines, however, the work has progressed famously, and in face of a progress at the East Heading during the previous year of about 590 feet, has to show 1277 feet of actual advance, notwithstanding a heavy drawback from unusual deficiencies in the supply of water power, by which the compressed air was furnished to the machines.

In connection with this improvement in the drilling machines, we will quote a remark of much importance, when its relations are understood, which occurs in Mr. Latrobe's report, p. 31. After describing the improvement in the Burleigh drill, he remarks:

"While saying this, however, I do not feel prepared to pronounce it the *ne plus ultra* of a machine drill, nor to give up the expectation that one with fewer parts and of more compact and simpler structure will, in due time, be designed and made to yield even better results at reduced cost. There is now lying in the shop, at the east end, a machine invented by parties from Michigan, differing in several respects from the Burleigh drill, although claimed, as I am told, to conflict with patent rights in the latter. Of this part of the case

I know nothing as yet, but the machine has been reported to me as working with great efficiency and small cost of repairs, on account of its fewer parts and simpler construction. It seems to have been introduced into the tunnel by the late contractors, and to have been disused on their retirement from the work; but from what reason, I am unable to state, as its performance is said to have been exceedingly promising of improvements over previous machines."

From this remark, it will be seen that Mr. Latrobe belongs to that large, but we are happy to say daily decreasing class of engineers, who do not read the *Journal of the Franklin Institute*, otherwise he would have known that the machine in question was invented by Professors Wood and Robinson, and exhibited many important features of novelty and improvement.

The cause of its disuse we believe (though this is unauthentic and simply on the ground of a general impression), was a little of the "dog in manger" policy, on the part of those controlling the other machine.

It appears from these reports, that during a large part of the past year, the work at the tunnel was under the personal supervision of one of the State Commissioners, Hon. Alvah Crocker, who pushed forward the work with great energy and marked success. During three months, part of the work was prosecuted under contract by Messrs. Dull, Gowan, and White, who were the contractors for the Chicago Lake Tunnel.

There appears to exist a difference of opinion between the Commissioner Superintendent, Mr. Crocker, and the Consulting Engineer, Mr. Latrobe, on several important subjects.

Thus the former advocates the prosecution of the work by the State for some time longer, before any resource is had to working by contract, in order that the very expensive preliminary works already constructed may be utilized, and made in this sense, remunerative to the State. He also calls attention to the fact, that the rate of progress under contract with Messrs. Dull & Co., was decidedly less than under his own supervision acting for the State.

Mr. Latrobe on the other hand, adheres to his previous opinion as to the advantage of the contract system, and shows that the cost of the work executed under contract was in a marked degree less than that carried on by day labor for the State.

Again, with reference to the pumping machinery for the main shaft and west shafts. Mr. Crocker has used so far with success, and advo-

cates for the future, cheap, compact and light, fast running pumps, such as those of Knowles & Sibley, placed at the bottom of the shaft with their boilers and furnaces, which thus assist in the ventilation. Mr. Latrobe, on the contrary, advises the erection of large Cornish pumps at the mouth of the shaft, even at a very heavy outlay. The relative merits of these plans will depend much in the present case, upon the length of time for which the pumping process will be continued.

With reference to the use of Nitro-Glycerine, Mr. Crocker speaks sanguinely, and describes arrangements which he has made to give it a thorough trial, and to manufacture the article on the ground. Want of space precludes our saying more on this subject at present, but in our next issue we will return to it, and give in full the report of Mr. G. W. Mowbray, who has undertaken the manufacture of this powerful explosive.

In this connection, we would also refer to the article on Nitro-Glycerine, in the present number p. 40.

Continuous Profile Paper, by James W. Queen & Co. Every engineer who has had any experience in that direction, is feelingly aware of the annoyance and difficulty attending the use of sheets of profile paper which have been attached to each other by pasting, for the purpose of producing such a continuous roll as is required in survey of long railroad lines. It would be useless for us to enumerate the difficulties resulting from uneven surface, want of fit, &c., which are thoroughly realized by all. The great value of an article such as the continuous profile paper, a minute fragment of which is appended as a specimen herewith, which is 22 inches from top to bottom, and of any length that is desired, and last but not least, costs but 30 cents a yard, will therefore at once be realized. Nor is the use of this article confined to the engineer. The student and experimenter in nearly every branch of science, continually requires some similar means for projecting and comparing results and observations, in one or other of the methods so ably discussed by Prof. Mayer in his "Lecture Notes," which have appeared from time to time in this *Journal.*

The subjoined letter gives the opinion of skillful engineers of long standing, in regard to the merit of the Continuous Profile Paper:

PHILADELPHIA, *Jan.* 31. 1868.

MESSRS. JAMES W. QUEEN & CO.

Gents:—We have examined your Continuous Profile and Cross

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PLATE B.—Horizontal " four to the inch.
Vertical " thirty to the inch.

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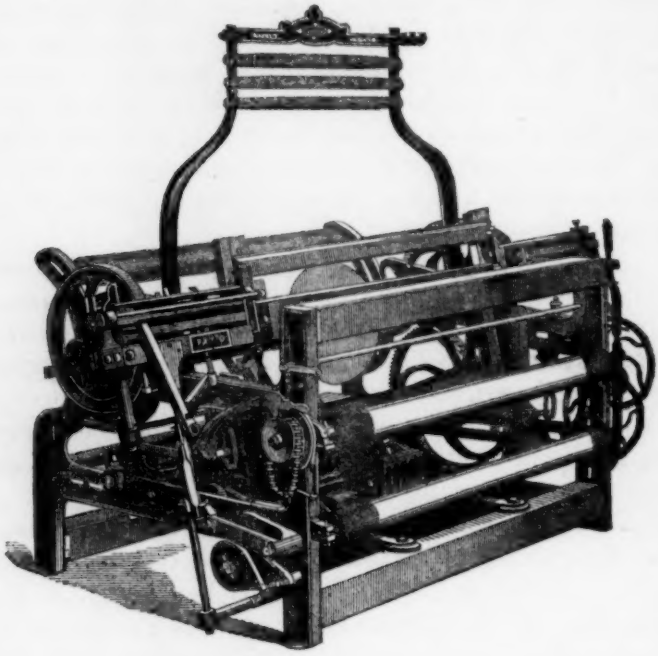
Section Paper, and have no hesitation in pronouncing it a great improvement over the sheet plan in which such papers have been heretofore printed. The want of this kind of profile paper has been much felt for years past, particularly on surveys of long railroad lines, for, in joining the ends of different sheets, we have found it extremely difficult to do it, or have it done with accuracy, on account of the unequal shrinking of the paper in printing and drying; for this reason only, your Continuous Paper will supersede the Sheet Profile Paper; but, in addition, we notice the price of your Continuous Profile Paper is less than we have always paid for the same article in sheets. This, we consider, adds very much to the merit of your invention.

STRICKLAND KNEASS, *Civil Engineer.*
JOHN C. TRAUTWINE, *Civil Engineer.*
W. H. WILSON, *Ch. Eng. Penn'a R. R.*

Power Looms.—As Lowell, Fall River, Lawrence and Manchester, in the Eastern States, are noted for the manufacture of plain cottons, such as print cloths, so is Philadelphia famous for its cotton checks, ginghams, plaid flannels, balmoral skirts, and such cloths, in which filling of more than one color is used. Thirty-five years ago, all checks, ginghams and plaids of all descriptions were the production of the hand loom. It was about 1833, that the first double box power loom was started in this country by the late J. C. Kempton, at the Schuylkill Factory, at Manayunk (now Twenty-first Ward of this city). Mr. Kempton was the first manufacturer who attempted the production of plaids on the power loom. His experiments were attended with great success, but met with great opposition from the hand loom weavers, and threats and attempts were made to burn the factories of Mr. Kempton in 1837. Other manufacturers, seeing the success of Mr. Kempton, and the great profits attending the manufacture of plaids on the power loom, had many of their single box looms altered, and others made to weave from two to four colors of filling, and at the present day, thousands of double box power looms are running in Philadelphia and vicinity, and not ten hand looms are now to be found making checks or ginghams. One firm at Manayunk has about 500 to 600 double box power looms on checks and ginghams, producing from fourteen to fifteen thousand yards daily.

Since the first double box power loom was started at Manayunk by Mr. Kempton, many improvements have been made in power

looms for weaving plaids. The following illustration shows a power loom for weaving with two colors of filling, called a two box loom, the manufacture of Mr. Thomas Wood, of this city, at his loom



works, Twenty-first and Hamilton streets. Mr. Wood was one of the first of our mechanics to engage in the building of double box power looms, and has made them a specialty, and with about twenty years practice and experience, he has in that time added many improvements. The above cut represents one of his looms, in which the box motion is of the star pattern, and for operating two shuttles or two colors of filling. This form of box motion is considered very simple, durable, and capable of being run at a great speed, as high as 140 picks per minute. One of the improvements introduced by Mr. Wood, is the casting of the shuttle-box in one piece, no bolts or rivets being used, as was formerly done in those made of brass, wrought or malleable iron. There is less liability to get out of order, and a capacity of running at a great speed. In this loom, the filling stop motion is connected with the pawl that operates the pattern chain of the box motion, which acts on the pawl instantly

by raising it, and preventing it from changing the pattern when the filling is broken or exhausted in one of the colors, thereby saving filling or yarn, and time.

The stop for the shuttle is independent of the box, and is worked by the motion of the lay. It has been much improved of late by adding a spiral spring to the under part of the stopper, to receive the force of the shuttle as it enters the box, which effects a great saving of pickers and shuttles, and is not so liable to break the filling, or jar off the bobbin or copp.

Mr. Wood is applying other improvements to his looms, for which he now has patents pending before the patent office. See his advertisement in the columns of this *Journal.*

Philadelphia and New Hope Railroad.—The route of a proposed railroad from Philadelphia to New Hope is being surveyed, and the engineers announce that easy grades can be found over a large portion of it, leading through an extremely rich and fertile country.

A "red line" car containing through-freight started a few days ago from Boston to Cheyenne, 2050 miles. The freight will go through without breaking bulk.

Progress and Effect of R.R. Consolidation.—In the infancy of what has grown to be a vast and complicated system, intimately interwoven with all the interests of the State, it was natural and proper that short roads for local business should be built. Through-lines only existed in the imagination of some men ahead of their time. As other roads were needed they were constructed. Rival routes were laid out. The grain from the West, the cotton from the South, called for cheap, quick transportation to the seaboard, to be exchanged for groceries and manufactured goods. There was no resource but to condense, centralize, consolidate. With larger capital, influenced less by local interest and managed with vastly more energy, the consolidations could and did offer greater facilities for business, and traffic took advantage of these facilities.

From New York *via* Philadelphia and Pittsburg, to Cheyenne, at the base of the Rocky Mountains, a distance of 1917 miles, but three changes of cars are made, and five companies control the whole distance. Between New York and New Orleans, 1500 miles, there are ten different roads, while between New York and Charleston, only 788 miles, there are also ten.

If the prices in the stock markets can be considered a test of value,

stockholders certainly should favor consolidation. Take up the stock list and compare the prices of the stock of those companies formed by agglutination—by link added to link—a new line made here, a branch extended there with that of those formed complete, whose termini are hundreds of miles apart, and between which there is a wilderness.

In England, where they are much in advance of this country in matters pertaining to railroad science (with the exception, perhaps, of bell-ropes), the tendency and practice has been to consolidate, and it has been carried to the extreme, and yet none of the evils which are often predicted here have resulted there. In 1844 a bill passed Parliament, providing that all roads chartered thereafter could be purchased by the Government after twenty-one years. This bill covers over five-sixths of the roads in the kingdom. The propriety and practicability of such purpose is now being discussed. The measure was proposed and carried through by Mr. Gladstone, and it is not improbable that he may take it in hand again. The consolidations or amalgamations, as they are called there, of the thirteen great lines, are almost numberless.

The London and North-western, the greatest company of the kingdom, with 1307 miles of road, is composed of twenty-eight companies; the business per mile carried on some of which, as the Liverpool and Manchester, and London and Birmingham, surpasses anything our roads can show. The North-eastern is composed of fourteen, the North British of eleven, the Manchester, Sheffield, and Lincolnshire of thirteen companies.

In France the State must do everything. A wise legislation has now, however, freed the Treasury from any ownership in any of the roads, and a very general supervision is all that it retains. There have been projected and partly aided by the State six great lines, now entirely owned by corporations.

First.—The Northern line from Paris to Calais, Boulogne, Dunkirk, and the Belgian frontier.

Second.—The Western line from Paris to Havre and Dieppe.

Third.—The Orleans or Central line, from Paris to Orleans, Bordeaux, Nantes, &c.

Fourth.—The Southern line, from Bordeaux to Cette Bayonne, Toulouse, &c.

Fifth.—The Paris, Lyons, and Mediterranean line from Paris to Marseilles, with branches to Cette Bayonne, &c.

Sixth.—The Eastern line from Paris to Strasburg, Chalons-sur-marne, &c.

A glance at the map will show that these lines were laid out not only with a view to the demands of traffic in times of peace, but as offensive and defensive lines in times of war.

In ninety-nine years from 1852, the roads are to revert to the State, suitable provision by means of a sinking fund or an equivalent being made for the stockholders. A similar law obtains in Prussia, the Government agreeing to pay the stockholders an amount equal to twenty-five times the average dividend for the preceding five years. In Belgium the State owns all the roads, and in lowness of fare, economy of working, and excellence of arrangements, they equal all and surpass most of the European roads.

We append a table, showing the cost, length (excluding branches leased), and cost per mile, of some of the longest American and English roads.

Railroads.	Cost.	Length, including branches owned.	Cost per Mile.
Erie	$48,507,541	459	$105,680
New York Central	34,133,911	550	61,500
Pennsylvania	21,135,439	387	54,600
Atlantic & Great West	56,357,560	387	145,630
Chic. & North-west	43,234,929	800	54,040
Mobile & Ohio	17,922,359	469	38,250
Illinois Central	41,478,280	708	58,590
Pitts. Ft. W. & Chic	23,841,274	529	45,070
	$286,611,293	4,294	$66,747
Caledonian	£21,200,283	573	£36,967
Great Eastern	28,123,000	709	39,426
Great Northern	20,519,569	487	44,709
Great Western	49,246,137	1,311	37,564
Lancaster & Gerk're	22,475,855	403	55,771
London & N. Western	56,180,613	1,307	42,308
London & S. Western	16,460,557	503	32,725
Midland	30,679,036	761	40,743
North-eastern	39,023,507	1,229	31,752
South-eastern	19,891,311	330	60,277
North British	18,799,778	752	25,133
Manch., Sheff. & Lon	15,336,341	246	62,343
	£337,935,978	8,611	£39,245

or in dollars at five to the pound sterling, we have 8611 miles of railway, costing $1,689,679,890, gold, or $196,225 per mile. Some of the shorter roads cost much more than this. The North Lon-

don, eleven miles in length, cost the enormous sum of $1,352,935, gold, per mile. The London, Chatham, and Dover, cost for its one hundred and thirty-six miles $704,020, gold, per mile. The nearest approach to these enormous sums in this country is in the construction of the connecting railroad through Philadelphia, uniting the New Jersey roads with the Pennsylvania Central, and Philadelphia, Wilmington and Baltimore roads. In the report of the consolidated companies, the President estimates the cost of constructing these seven miles at $2,000,000—nearly $300,000 per mile.

The Spectroscope and the Bessemer Process.—Almost with the first announcement of the action and indications of the spectroscope, it was proposed to apply it in the manufacture of iron as an indicator of the progress in change or conversion of the material. See this *Journal*, Vol. XLV. p. 128. After many and various experiments, which we have from time to time noticed, it is now at last announced that a satisfactory result has been reached by Prof. Lielegg and Dr. Roscoe, and that in the Bessemer process, the proper moment for stopping off the blast and introducing the spiegeleisen can be determined by observation of the flame escaping from the converter, with a spectroscope. The order of changes in the spectrum are from first to last as follows: When the charge is started, a luminous spectrum appears, due to the volley of sparks, with no lines; soon after the sodium line is seen, followed by those of iron, lithium, potassium, hydrogen, nitrogen, and a number of bright lines with very dark spaces between, due perhaps to carbonic oxide and perhaps to carbon vapor, which occur principally in the green, these again disappear in inverse order to that of their development, and their total or partial extinction is the signal for the stoppage of the blast, and introduction of spiegeleisen.

The Town of Belfast, Maine, alive to the importance of having a direct connection with the Main Central Railway, has voted $600,000 to build a connection.

Improved Air-Pump.—By E. S. Ritchie, Esq., of Boston, Mass. A good air-pump, which will produce with certainty a vacuum approaching the Torricellian, is becoming almost a necessity, and certainly a most desirable possession to every physicist who is called upon to demonstrate to his classes the new developments of electrical science. In view of this fact, we are glad to receive and publish the following account of an air-pump, containing many new features,

devised and constructed by Mr. E. S. Ritchie, who is already so well known for the great improvements which he has introduced in the Induction Coil, Holtz Machine, and other Philosophical instruments, as well as by his Liquid Compass, and other valuable devices.

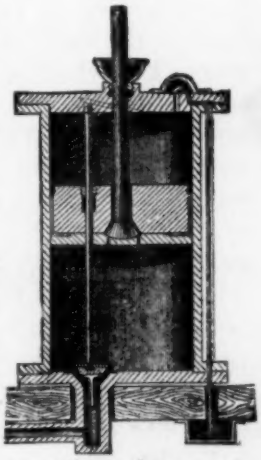
This new pump, with automatic valves above mentioned, may be described as follows:

The cylinder is made in the usual form. The motion may be given to the piston-rod by crank or lever. The peculiarities are in the construction of the piston and valves, and also in the manner in which motion is given to the valves.

Fig. 1 is a section showing the valves, &c., much exaggerated for distinctness.

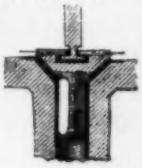
The lower valve is conical, held in place by a triangular stem fitting the tube; it is raised by the *valve-rod* passing up through a stuffing-box in the piston; an enlarged section (Fig. 2), shows the manner in which the attachment is made, which allows a motion of the rod sidewise, so that any slight change of form of the packing of the piston, or stuffing of the rod, cannot prevent the valve from shutting properly. The cone of the valve is ground to a perfect fit to its seat, but the valve is also furnished with a disk of oiled silk, which projects just beyond its outer edge, and touches the flat surface of the valve-seat; the valve-rod extends up, and its upper end is secured in a hole drilled in the upper plate, of depth to allow motion vertically to open the valve.

Fig. 1.



The *piston* is of thick brass, made in two parts, the upper piece has a hole drilled larger than the piston-rod; the lower part of conical form, ground to fit a cone on the piston-rod; this forms the piston-valve. The lower piece of the piston covers the end of the piston-rod, but allows it enough motion to open the valve; a series of small holes through the plate gives a free passage for the air to the valve.

Fig. 2.



A third valve is placed outside the cylinder, made of oiled silk in the usual way.

In the thickness of the upper plate of the cylinder is inserted a

steel lever, one end of which covers the valve-rod; the other end, when the lower valve is closed, is *flush* with the plate; but when the valve is raised it projects into the cylinder.

In action, the first motion upward of the piston-rod closes the piston-valve; the first motion of the piston opens the lower valve; as the piston ascends, the air above it is forced out through the upper valve; and air from the receiver flows unobstructedly into the cylinder. The piston strikes the tail of the lever, and at the instant of arriving at the top, closes the lower valve. The first downward motion of the piston-rod opens the piston-valve, the air remaining in the interstices above the piston distributes itself equally throughout the cylinder, but *none* can pass the lower valve back into the receiver. When the piston again reaches the bottom of the cylinder, the interstices below are filled with air as *rarefied* as a pump with ordinary valves can exhaust. The working parts are very substantial, not likely to be deranged, and are readily accessible.

Almost a Torricellian vacuum is obtained; a mercury gauge is brought within *one-fiftieth* of an inch. The Aurora Tube is filled with brilliant stratified light, in connection with the Induction Coil; water is frozen without acid, &c.

Transparent Sheet Gelatine.—On page 500 of the last volume, we published a short description of a new kind of magic lantern transparency, made upon the above substance, by Mr. Outerbridge, who has also prepared the gelatine in the following manner: A sheet of plate glass, of any desired size, is carefully cleaned and polished. There is then rubbed over its surface a very small quantity of oil (passing an almond over the plate answers excellently). The ordinary gelatine is dissolved in water and poured over the plate, which is then allowed to stand for about twenty-four hours. The gelatine has by this time hardened, and may be peeled off. It may be made insoluble in water, by mixing with it while fluid a small quantity of bichromate of potash. The most beautiful colors may be produced, and we have found the colored gelatine very useful for various purposes in the magic lantern. As for example, the disk, having seven different colors (Newton's recomposition of light), which being rapidly revolved, produces upon the screen a disk of white light. In the experiment of the reflection of light in a liquid vein, colored gelatine sheets may be used instead of stained glass, and are of course much cheaper and more easily put together.

New Railroad Bridge at Port Clinton.—The Port Clinton (Pa.) reporter of the *Reading Eagle* says: The Philadelphia and Reading Railroad Company have again commenced work on the new railroad bridge across the Schuylkill River at this place. It will probably be completed during the summer. It connects with the main road (to be constructed) from Port Clinton to Topton on the line of the East Pennsylvania Railroad.

The Missouri Pacific Railroad returns as gross receipts, for passenger and freight transportation, exclusive of Government transportation and tax, $2,536,445 for 1867.

The Brooks' Insulator in England.—Early last year it was announced that Monsieur Vicomte de Vougy, Director General of the Telegraph Lines of France, had appointed a commission of electricians to decide upon the style and material of an insulator for telegraph lines under his charge. This commission was composed of eminent electricians, among whom were Monsieurs Gaugain Gavorect, Du Moucel and others, whose names are familiar to all readers of works on electrical science. The most approved insulators of the different countries in Europe were procured and tested in the open air, exposed to the weather. Among others presented for trial was that of Mr. Brooks, mentioned in this *Journal*, Vol. LV., page 10, and also at page 149. After three months of trial, an order was given, on October 1, 1867, to Mr. Brooks for a sufficient number to enable the commission to make a practical test of their value. The result of this examination and test was made known through the columns of the *Semaine Financiere* of January 24, and *La Union* of February 4, stating that the Brooks had proved far superior to all its competitors. (This was reported in our March number for this year.)

The English Telegraphers hearing of the success of this Insulator, sent to Philadelphia for samples to test in comparison with their own in the fogs and mists of London.

A table of results, which has just been received, and is printed below, speaks for itself, and shows that the merits of this instrument are not lost by a change of climate or a transfer to hands in no wise interested in their development or exhibition.

We were present lately at a series of tests of the Brooks and other Insulators, made in this city, which fully confirmed the results obtained at Silverton, as shown in the following table. These we will give in full in our next issue.

TEST OF INSULATORS

MADE AT INDIA RUBBER, GUTTA PERCHA AND TELEGRAPH WORKS CO., SILVERTON ESSEX, ENGLAND.

CONSTANT OF GALVANOMETER, 1 DANIEL CELL, THROUGH 1,000,000 OHMADS.	Date	March 1st, 1868.	March 9th, 1868.	March 20th, 1868.	March 26th, 1868.	March 31st, 1868.
	Temperature	47° Fahr.	49° Fahr.	52° Fahr.	48° Fahr.	43° Fahr.
	State of Weather	Very Dull.	During and after rain.	Atmosphere damp.	During and after much fine rain.	During a thick fog and frost.
	Constant of Inst	334	336	335	333	327
	Numb. of Cells	500	100	500	500	500
DESCRIPTION OF INSULATORS.	Number of Insulator tested.	Deflection in degrees in Thomson's Astatic Galvanometer per Insulator.	Deflection in degrees in Thomson's Astatic Galvanometer per Insulator.	Deflection in degrees in Thomson's Astatic Galvanometer per Insulator.	Deflection in degrees in Thomson's Astatic Galvanometer per Insulator.	Deflection in degrees in Thomson's Astatic Galvanometer per Insulator.
United Kingdom Telegraph Co., large procelain	4	3,500	330	20,000	10,600	40,000
Varley's Double Porcelain Cup	4	4,500	450	37,500	25,000	50,000
British and Irish Magnetic Co., porcelain	4	30,000	1,600	35,000	18,500	90,000
United Kingdom Telegraph Co., small porcelain	4	800	150	11,850	14,500	50,000
Brooks' Patent Insulator with 6-inch Screw Shank	5	2	0	2	1	4
Do. do. do.	6	8	0	11	6	4
Do. do. do.	6	7	0	4	6	1
Do. with lug for cross arm	1	200	80	194	80	3

(Signed) MATTHEW GRAY,
Engineer and Manager.

(Signed) MATTHEW GRAY,
Engineer and Manager.

Civil and Mechanical Engineering.

PNEUMATIC BRIDGE FOUNDATIONS.

By O. Chanute, C. E.

(Continued from page 391.)

The cylinder being thirty-five feet in diameter, it was out of the question to maintain, with the ordinary pneumatic machinery, the necessary pressure and volume of air for a sufficient number of workmen, operating at a depth of eighty-two feet, or under a pressure of two or three atmospheres. It was evident that the working space must be made as small as possible to ensure success. With this view, Mr. Brunel divided his cylinder in two parts; the bottom portion was provided with a spherical dome, under which the plenum was to be maintained, and the upper portion was so arranged that it could be removed after the masonry was built up. In the lower portion, there was under the dome an annular partition, concentric with the cylinder, divided into compartments, communicating with the exterior works by a pneumatic tube enclosed in another tube of greater diameter. This pneumatic tube was used in forcing air into the annular chamber, while the enclosing tube served to withdraw the materials excavated. As soon as the mud was removed from the annular space in this species of diving bell, masonry was built in its place, fitting accurately the rock bottom and iron sides, so as to shut out the water. This operation completed, it was contemplated to remove the inner dome and the pneumatic tube, and to work in the open air, in the centre of the masonry ring thus laid inside the cylinder.

In case of infiltrations, it was believed that ordinary pumps would suffice to keep the water down. Unfortunately, the space enclosed by the inner cylinder was found far from dry, the pumps moved by portable engines mounted upon the cylinder being unable to keep down the water, flowing in through crevices in the rock bottom. It became necessary to employ for this middle space the same process as for the annular chambers, and to resort to compressed air.

We believe that the founding of this pier occupied nearly three years, and that the health of the workmen suffered so seriously from the great air pressure which had to be maintained to counterbalance the water pressure (from two to three atmospheres), that

continental engineers are agreed that twenty-five metres (eighty-two feet), is about the extreme limit to which it is advisable to carry the plenum process.

Russian Bridges.—In building the railway from Warsaw to St. Petersburg, and its branches, very similar circumstances to those which obtain in this country were encountered. The country was sparsely settled, foundries and machine shops few, and means of transportation difficult. Rivers had to be crossed, resembling much in their régime our western streams, while the variations of temperature and ice freshets, were fully as severe as with us.

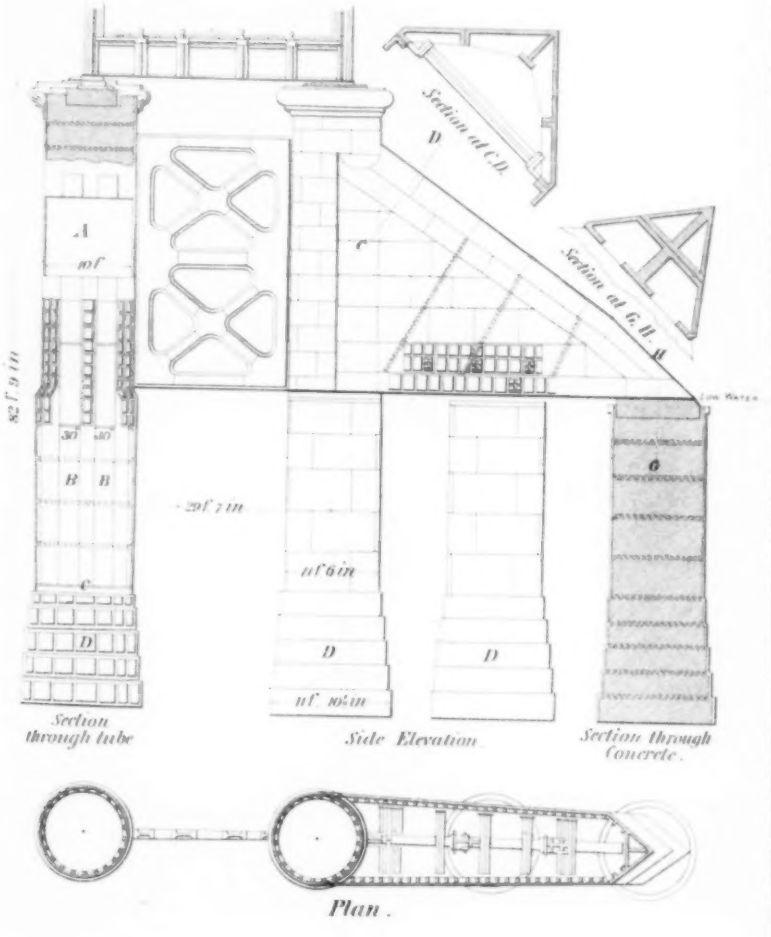
As no stone but a few scattered boulders was to be obtained, it was decided to make large use of tubular iron piers and foundations. The following is a list of some of the principal bridges on that line.

Name of River.	Length of Bridge.	Number of Spans.	Number of Tubes in each Pier.	Diameter of Tubes.	Total weights of iron for Superstructure, Piers, and Ice Breakers.	
					Cast Tons.	Wrought Tons.
Dwina.....	874 ft.	3	4	14 ft. 9 in.	1768	3242
Niemen, at Kowno	985 "	4	4	11 ft. 6 in.	2100	1966
Bug.....	929 "	5	3	9 ft. 10 in.	1275	1642
Niemen, at Grodno	618 "	3	3	11 ft. 6 in.	1113	1324
Narew.....	559 "	3	2	9 ft. 10 in.	374	932
Vakka.....	274 "	3	2	6 ft. 6 in.	260	281
Vileika.....	250 "	3	2	6 ft. 6 in.	212	242

These bridges are all for double track, with wrought iron superstructure, and were built by contract by Mr. E. Gouin, of France, from 1859 to 1862. The piers are all of cast iron tubes, protected by ice breakers, and filled with a concrete composed of Portland cement, 1 part; sand, 2 parts; broken stone, with a small quantity of brick, 3¼ parts.

Plate III. gives an elevation and plan of those for the Kowno bridge over the Niemen.

Kowno Bridge over the Niemen.



As all the iron work and castings were to be brought from France, Germany, and England, it was important that they should be of some form more easy of stowage and transportation than the ordinary full cylinder sections used in the pneumatic process; this could only be accomplished by multiplying the joints, while even with the usual form, considerable difficulty and loss is occasioned by the leakage of the compressed air between the flanges. To obviate these two opposite difficulties, and inspired by the success of the modified process employed at the Kehl bridge, which will hereafter be described, important changes were made in the arrangement of the tubes. The compressed air was confined to a working chamber, D, 15 feet high, of riveted wrought iron plates, at the bottom of the tube, closed at top by a diaphragm plate C, made in two halves for convenience in withdrawing, and connected with the air lock, A, by two service tubes of wrought iron, B B, 30 inches in diameter, and provided with internal ladders and hoisting gear. The volume of air to be supplied was thus reduced to the smallest possible quantity, leakages avoided, and great economy of both money and time secured. The diaphragm effectually protected the workmen from the fall of any stone, timber, or material from above, while it left the whole inside space above it available for ballast to sink the tube. Water was used for this purpose, being much cheaper and more easily handled than the rails or heavy cast iron weights generally employed elsewhere. The workmen went in and out, and the excavated materials were withdrawn through the service tubes, which were built in sections 4 feet 11 inches high. All the joints of the air lock and the working chamber with the diaphragm and service tubes were bolted together with rings of India rubber between the flanges.

As with this arrangement, leaks were no longer to be feared in the main tubes above the working chamber, their sections were cut up into four segments, provided with internal flanges, and securely bolted together.

As soon as the column was sunk to its intended depth, the working chamber was filled with concrete to a height sufficient to counterbalance the water pressure, the diaphragm, air lock and service tubes withdrawn for future use, and the remainder of the column filled with concrete in the open air.

Each pier of the Kowno bridge consists of four such columns, 11 feet 6 inches in diameter, sunk to a depth of 39 feet below low

water, through granitic sand. They rest upon a stratum of hard clay, and are embedded on an average about 33 feet in the sand. All parts exposed to shocks are 2½ inches thick. The two up stream columns support an ice breaker of cast iron plates 2½ inches thick, bolted together through internal flanges, and the other two columns support the trusses of the bridge.

The abutments consist of two columns of the same size, sunk to the same depth as the piers, the ice breakers being omitted.

It is stated that these columns, sunk in 1861, have stood ever since very well. The observed changes of temperature at the bridge site have been 135 degrees, or from —31° to +104° Fahrenheit. The ice, which frequently attains a thickness of two or three feet, and gorges when breaking up, so that sometimes the water rises and falls five and six feet in an hour, has had no effect upon their stability.

It need scarcely be pointed out that in a country like ours, where timber is cheap and iron dear, the iron working chamber could in certain cases be surmounted with a tube made of wooden staves, which could be filled with concrete or cut stone masonry, either after the column was down to the desired depth, or (when great penetration and consequent weight was required), during the progress of sinking.

The same contractors in 1860–1, under the direction of General Kerbedz, a distinguished Russian engineer, put in similar tubes for the foundations of the masonry piers of the bridge across the Vistula, at Warsaw.

The piers are protected with ice breakers, inclined at an angle of 45 degrees, and are faced with granite, backed with red sand stone. The masonry rests upon four columns; two of these, 18 feet in diameter, are placed under the bearings of the trusses, 35 feet 6 inches between centres. The other two, 9 feet in diameter, are placed, the one between the two large columns, and the other under the ice breaker. A cast iron grillage resting upon the edges of the columns, spans over the intervening spaces and supports the masonry.

The tubes were built like those on the St. Petersburg and Warsaw Railway, with a working chamber of boiler plate, 13 feet high, surmounted by a cast iron shell, divided into 4 segments per section for the small columns, and 12 for the large ones. A wrought iron diaphragm, shaped like a truncated cone, formed the top of the

working chamber, and supported the water or soil which composed the ballast. The working tubes were connected with this diaphragm, and the excavated materials extracted through them.

The columns were sunk to a depth of 49 feet below low water, and a bed of concrete being laid for a few feet, solid masonry was filled in the tube above it. A coffer-dam built around the tubes, was then pumped out, the upper portion of the tubes disconnected and withdrawn, the grillage put in place, and the pier built.

The work was done rapidly, *of its kind*, the tubes of the first pier having been sunk and filled with the concrete foundation during the first season, and in the second season, that of 1861, the 16 tubes of the last four piers were put down.

Bridge at Orival.—The latest bridge founded with tubes, of which we have a description, is that over the Seine, at Orival, built in 1863 and 1864. Both the piers and abutments are formed of cast tubes, 11 feet 9 inches diameter, spaced 28 feet 6 inches between centres. The cutting section is $2\frac{3}{4}$ inches thick, the intermediate 2 inches, and the upper sections $1\frac{1}{2}$ inches. The reader will find a full description of this bridge in *Engineering*, of February 1st, 1867.

The chief advantage offered by the use of the plenum process, lies in the complete command which it gives over the removal of obstacles. The process of excavating in compressed air, and of withdrawing the materials through an air lock, however, is both tedious and expensive. At the Theiss bridge, the workmen in the tube averaged only $\frac{9}{10}$ths of a cubic yard per day each, while as much as $15 per cubic yard has been paid by contract at other bridges. At Orival, the solid cubic contents of that portion of the columns sunk into the soil, averaged 147 cubic yards, and the average cost of sinking was $1786.46 each.

Where but few obstacles are to be expected, it may be much cheaper to employ other methods of excavation. Thus, in putting down tubes of 8 feet 4 inches diameter, to form the piers for the bridge over the Clyde, last year, Mr. Milroy sank them down 75 feet through sand, without the use of compressed air, and at a cost inside of one dollar per cubic yard removed, by the use of the ingenious machine figured and described in the number of *Engineering*, for December 6th, 1867; while wrought iron tubes 14 feet in diameter, have recently been sunk at one of the bridges now building across the Mississippi, by excavating inside with a vertical dredge, at a cost of about $750 per tube.

Part II.—Caissons.

In the improvements of the pneumatic process, which remain to be noticed, of substituting caissons for tubes, and putting in the foundations and building the pier simultaneously, the materials excavated have been withdrawn without passing through the air lock at all, while much greater rapidity of execution and stability of work have been secured.

Kehl Bridge.—When, in 1858, the governments of France and of the Grand Duchy of Baden, entered into an agreement for the purpose of building an international bridge over the Rhine, at Kehl, in order to unite their respective railway systems, it was at first contemplated to employ pneumatic tubes for the four river piers. Drawbridges being required adjoining each bank of the river, the piers next to the shores were to be of masonry, founded upon tubes, and the intermediate piers of columns carried up to the bridge seat.

The International Commission of Engineers, however, entrusted with the elaboration of the plans, came to the conclusion, that at this very difficult point, tubes would not afford sufficient stability.

The bed of the Rhine, at Kehl, is composed of sand, gravel and silt, of nearly indefinite thickness, in which scour is known to occur to a depth of 55 feet below low water. The stream is subject to frequent freshets, and sometimes attains a speed of 9 to 11 miles per hour; and it was feared that isolated columns, offering but little weight and base in proportion to their surfaces, might not resist the thrusts produced by unequal scour upon their opposite sides, and would offer but slight resistance to lateral shocks or shoves. It was besides objected to columns, that as but one tube could be sunk at a time, the founding of the four piers would occupy more than one season between freshets; that serious troubles had been experienced at other bridges in penetrating with tubes to a lesser depth than was thought necessary here (65 feet), and that besides the ungraceful architectural appearance of columns for the intermediate piers, as it would be necessary to give the iron great thickness to resist shocks, a large quantity of metal would be employed; and that it would be both cheaper and more expeditious to employ a different system.

Under these circumstances, the commission decided to adopt a modification of the pneumatic process, proposed by M. Fleur St.

Denis, the principal assistant engineer; which, although it did not realize the full measure of economy expected at the Kehl bridge, in consequence of the needless complications and difficulties always besetting a novel undertaking, was more rapid in execution, and has since, at other works, proved cheaper than tubes, while it affords very much greater safety and stability.

M. Fleur St. Denis proposed to sink down the whole pier of masonry to a depth of 65 feet below low water, by undermining and excavating under it, during the process of building, in an inverted plate iron caisson filled with compressed air, which should support the masonry above; and to withdraw the materials excavated through chimneys left in the pier.

It was arranged that the French Railway Company, of which M. Vuigner was chief engineer, should put in the foundations and build the masonry, while the Baden company, of which M. Keller was the chief engineer, should erect the iron superstructure. M. Fleur St. Denis was placed in charge of the foundation works.

The size of the foundations of the piers next to the shores, was 77 feet by 23, and of the intermediate piers 57 by 23 feet. It was at first proposed to build a single caisson for each, but some of the engineers consulted, feared that so long a body in proportion to its width might lurch in the process of sinking, and the space was divided into four separate caissons for the shore piers, and three for the intermediate piers,

Plates IV. and V. give a general idea of the process adopted, as carried out at the shore piers. The foundation was made of four independent inverted caissons of three-eighths boiler plate, each 19 feet long, 23 feet wide, and 12 feet high, placed side by side, so as to occupy a total length of 77 feet, and weighing in the aggregate, 306,000 pounds. In the roof of each were three openings, the central one 4 feet 11 inches in diameter, and the two lateral holes 3 feet 3 inches in diameter. The latter were surmounted with wrought iron pneumatic tubes, provided with internal ladders and winches, and served merely for the passage of the workmen, and the introduction of compressed air as well as materials for construction inside the caissons. Each air tube was used alternately, the air chamber being fastened to the one, while the other was in process of being lengthened; and thus a cause of considerable delay avoided. In the central hole a tube was inserted, passing down through the inverted caisson, and extending one foot below its bot-

tom edge; inside this tube a vertical dredge was mounted, which extended, as well as the air tubes, through the body of the pier up to the surface.

The four caissons having been built side by side, upon a temporary floor erected over the intended site of the pier, were lowered into the bed of the river by suspension screws supported by the staging, and the building of the pier begun on top of them. At first the caissons were disconnected from each other, and each surmounted with a wooden curb, lined outside with thin sheet iron, into which concrete was laid as fast as the sinking progressed; but after the experience acquired in sinking the first pier, the division into separate caissons, and the wooden curb, having been found useless complications, they were dispensed with; the four caissons were strongly bolted together, thus forming but one, with three internal partitions, in which man-holes were cut to facilitate the movements of the workmen, and the pier built in one mass of concrete on top of the caissons; the rubbing surfaces being faced with hammer-dressed dimension stone.

The caissons being thus placed on the river bed, which had been levelled off to receive them, and the pier built up on top of them, so as to reach above the surface of the stream, compressed air was forced through the pneumatic tubes into the caissons, and the water expelled.

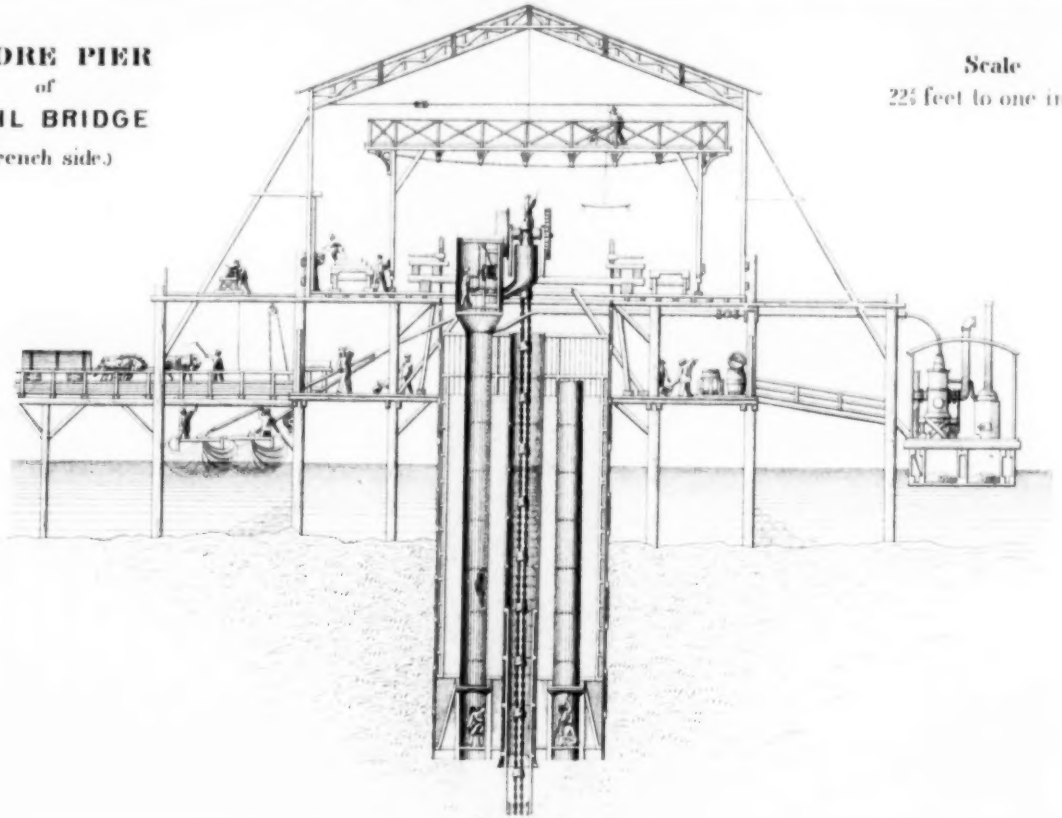
The central tube, in which the dredge was mounted, extending through and below the caissons, remained full of water at the same level as that in the river. Workmen were now introduced into the caissons, and standing upon a temporary floor, fastened to struts extending from side to side near the bottom, excavated the soil from the sides, and fed it under the edges of the central tube to the dredge, which raised it to the surface, whence it was conveyed in boats to the shore.

As there were thus to each of the shore piers, four dredges and eight pneumatic tubes, the work could be driven very fast. The first pier was put down in fifty-five working days, the second, profiting by acquired experience, in thirty-one; the third in twenty-five, and the last in twenty-four working days. The two latter being the intermediate piers, were of the reduced dimensions, were formed of three caissons, and had therefore but three dredges and six pneumatic tubes.

The piers were all put down to a uniform depth of 65 feet 9

SHORE PIER
of
KEHL BRIDGE
(French side.)

Scale
22½ feet to one inch.



Cross Section.

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inches below low water, the greatest depth worked at below the stage of the river being 72 feet 9 inches, and the greatest pressure of air about 3 atmospheres.

When partly down, the pressure of the surrounding soil buckled the sides of some of the caissons. This had been provided for; masons were sent down into the inverted caissons, and built brick arches between the sides, so as to take up the thrust against them.

In order to have still water to work in, the site of the pier was enclosed in sheet piling, and so as to carry on the work night and day, in all weathers, a shed was erected over the works, with two working floors or stories 11 feet 6 inches apart, as shown in the plate. Traveling crabs traversed on the upper floor, and the materials were brought directly to the work by a double track railway, laid on a temporary wooden bridge.

The air compressing engines were five in number, of seventy-seven aggregate horse-power, and were placed upon boats on one side, while the other was reserved for the dredge boats. The four dredges were worked by two steam engines, each of ten horse-power, erected upon the upper working floor. The dredge buckets extending below the bottom of the tube in which they worked, excavated a hole beneath the lower edges of the caissons, into which it was easy to push the materials excavated by the workmen along the sides. The cubic contents extracted (4903 cubic yards on the average), varied from 1·63 to 1·72 times the actual cubic contents displaced by the pier, while in the tube process, three times the cubic contents has frequently to be extracted.

The chimney of 4 feet 11 inches diameter having been found too restricted to work the dredges successfully, the iron tubes were dispensed with above the top of the caissons, after the first pier, and an oval brick chimney built, 7 feet 6 inches by 4 feet 10 inches, for the dredge to work in. Similar brick rims were built a few inches from the pneumatic tubes, to preserve them from contact with the concrete, so that they could be removed by divers after the pier was sunk to the intended depth.

In order to regulate the descent and prevent lurches, the suspension chains, which were fastened to the bottom of the caissons, were lengthened from time to time, and fed down gradually by screws worked by ratchet levers at top, as fast as the undermining of the pier proceeded. The masonry was built so as to keep the weight but slightly in excess of that required to overcome the friction, and

within the power of the screws to sustain. Thus, at the beginning of the operation of sinking the pier next to the Baden shore, the state of equilibrium was as follows:

Depth of immersion of caissons below the water, which was on that day 6·72 feet above low water	18·23 feet.
Depth of penetration into sand	7·67 "
Height of masonry above roof of caissons	15·15 "
The water being expelled, the lifting reaction was	2,249,808 pounds.
And the load to overcome it and the friction was	4,049,523 "

When this pier was put down to depth, the equilibrium was as follows:

Depth of immersion (water 4·75 above low water)	70·45 feet.
Depth of penetration into sand	40·37 "
Height of masonry above roof of caissons	47·82 "
The reaction of the compressed air was	7,345,162 pounds.
And the load to overcome it and the friction was	14,757,328 "
The rubbing surface in contact with the sand was	9,666 square feet.
And the useful load to overcome friction	767 pounds per square foot.

Theoretically, the friction should increase as the square of the depth, but an examination of the daily journal of sinking and equilibrium kept at the Kehl bridge, from which the above is extracted, as well as recent experience in some of our western rivers, show that this is not strictly the case, and that considerable discrepancies are caused by the variations in the character of the materials penetrated, the natural arches sometimes formed by the soil, and the difference between its friction of rest and friction of motion.

It will be noted that about one-half the useful effect of the weight was absorbed by the reaction of the compressed air, which was to that extent a detriment in sinking, while its use required powerful and complicated machinery, and added materially to the expense. The cost of excavating the materials with the dredges, was $3.84 per cubic yard, a material reduction over the cost in tubes, yet much more than it would be in open air. The chief value of the compressed air lay in the command it gave over the removal of obstacles, of which few fortunately were found in sinking. Two logs were met with under one pier, which were readily cut through, some brush-wood under another, some iron anchors were also found, and at a depth of forty-seven feet below low water, links of a chain, large nails, part of a horse-shoe, a knife, pieces of cast iron, &c.

The abutments were founded, by dredging in the open air, a pit

to a depth of thirty-nine feet below low water, allowing the material to assume its own slope, sliding a wooden caisson into position, filling it with concrete, and rip rapping outside. These abutments carry the turn-tables of the pivot bridges, one leg of each of which extends over the stream, and the other over the land.

In order to save the very considerable weights of iron in the caissons, M. Fleur St. Denis had proposed a further modification of his process, which consisted of making the caisson practically a diving bell lowered down through sand instead of water. He proposed to force it down by loading it with sand and water instead of the masonry of the pier, and after the desired depth was attained, to build the pier *under* the caisson in compressed air, gradually unloading and raising the latter as fast as each course was laid. This, although not impracticable, was thought to present such numerous chances of accident and delay, that it was not adopted, and it was preferred to carry out the original designs in which the caissons were allowed to remain under the masonry of the pier, and were filled with concrete as soon as the desired penetration was reached.

Notwithstanding this rapid method of putting in foundations, the bridge was a considerable time in building. Work was started in July, 1858, the operation of sinking the first foundation was begun in March, 1859, and the bridge opened to the public in April, 1861.

The cost of the Kehl bridge was as follows:

Grading, dredging, and preparing working yards	$ 36,735
Temporary bridge and scaffoldings	148,800
Foundation and masonry of shore pier, French side	141,360
" " " " Baden "	117,180
" " " inter. " French "	93,930
" " " " " Baden "	92,070
" " " French Abutment	144,150
" " " Baden "	140,430
Accessory works, river landings, &c	27,900
General expenses and superintendence	33,945
Iron superstructure for double track railway bridge	325,500
Total cost	$1,302,000

Which is of course very expensive for a bridge 771 feet long between abutments, or taking into account the legs of the two drawbridges which project over dry land, 1013 feet over all.

The mode of founding adopted at the Kehl bridge, was thus the origin of an important improvement in the pneumatic process. It

substituted one single mass of masonry for isolated columns, and thus added much to the stability. It made the weight of the pier useful in sinking, so that it could be built simultaneously with the excavation of the foundation, and substituted dredges for the former tedious and expensive mode of raising the excavated materials in bags or boxes. At every bridge where it has since been applied, its cost has been less than that of tubes giving the same area of base, while its permanency must be greater, and the cost of repairs less than those of any supports relying upon metallic envelopes. It can be applied equally well to the sinking of stone columns surmounting a round pneumatic caisson, and in some instances where companies had previously supplied themselves with tubes, these were altered so as to be sunk by the modified process with advantage.

Voulte Bridge. At the bridge over the Rhone, at La Voulte, the experience acquired at Kehl was utilized as follows:

The working chamber, instead of being divided into several compartments or independent caissons, was composed of a single inverted caisson $\frac{7}{8}$ths thick, and 8 feet 6 inches high. In order to permit the height of the masonry to be adjusted at all times to the weight required, the working chamber was surmounted with a coffer-dam or iron caisson $\frac{3}{8}$ths thick, carried up above low water, inside of which concrete was poured. The materials were excavated by a single dredge, placed in the centre, and the workmen went in and out through two air tubes.

The pier was, as at Kehl, suspended to lowering screws, which regulated its descent.

(To be continued.)

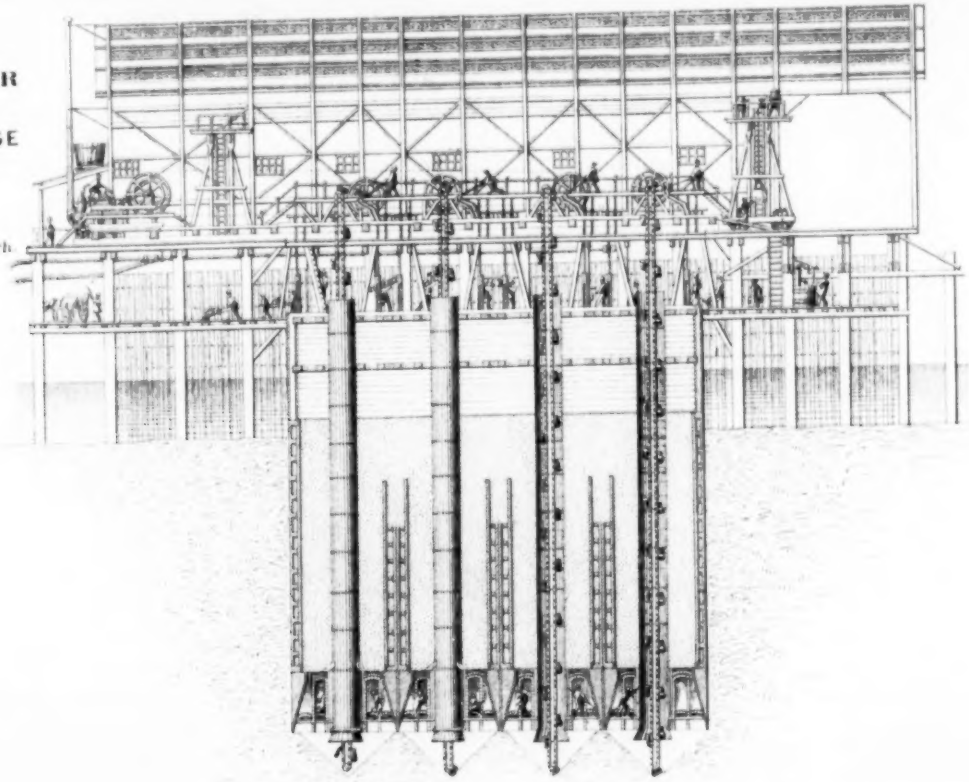
SUEZ CANAL—SUPPLEMENT.

By Chas. H. Rockwell.

The following calulations were made by Mons. Lavalley, with regard to the time which will be required to fill up the immense area known as the "Basin of the Bitter Lakes." The extreme length of this depression is about 22 miles, varying in width from $2\frac{1}{2}$ to 5 miles. The maximum depth is about 35 feet below the sea level. This basin is now dry, and has been so from the time of the earliest traditions. The bottom is now covered with a deposit of salt, from 6 to 20 inches in thickness, and the formation of the country

SHORE PIER
of
KEHL BRIDGE
(Frenchside.)

Scale:
33½ feet to one inch.



Longitudinal Section

shows conclusively that this was formerly the head of the Red Sea, and Mons. de Lesseps brings strong arguments in support of the idea, that here was the point of crossing by the Israelites, under the guidance of Moses and Aaron.

The surface area of this Basin is 170 million square metres; its cubic capacity is a thousand million cubic metres. The Mediterranean end of the Canal will soon be so far advanced as to give a cross-section equal to 200 square metres. This with a current of 11 inches per second will deliver a volume of more than five million metres per day. An allowance of a million and a half cubic metres per day is made for evaporation, and a total allowance of six hundred million cubic metres for loss by saturation—at the rate of three cubic metres for each square metre of the bottom. At this rate about 400 days will be required for filling. But the Suez end of the Canal will be so far finished before this period has elapsed, as to bring in about two million cubic metres per day, from the Red Sea; which will reduce the time to 250 days.

The capacity of Lake Timsah is about eighty million cubic metres, and the water from the Mediterranean has been flowing into this basin since December, 1866.

The greatest depth here is about twenty feet below the sea-level. This was formerly a fresh water lake, supplied by the overflow of the Nile, but has been entirely dry for ages. Henceforth, it will be a saltwater basin, supplied from the sea at either end of the canal.

The town of Ismailia, on the bank of the lake, has already a population of 4000 inhabitants.

The following facts may aid us in forming some idea of the possible or probable revenues of the Suez Canal.

About three million tons of shipping now annually double the Cape of Good Hope, engaged in the trade between China and India, in the East, and Europe and this country, in the West.

The rate of freight by railway between Alexandria and Suez, is now from 70 to 200 francs per ton, according to its classification. The Peninsular and Oriental Company, and the Messageries Imperiales pay about half these rates. The last named company are now sending their coal through the Canal at a cost of about 21 francs per ton, and at 25 francs per ton for heavy merchandize.

The saving in distance between the route around the Cape of Good Hope, and through the Canal, is shown in the table below.

The Island of Ceylon is chosen for the eastern terminus, in these calculations, as representing a point of mean distance in the Asiatic seas.

	Distance in Graphic Miles.		Per cent. of Saving.
	By Cape.	By Suez.	
London	14,340	7,300	49
Marseilles	14,500	5,490	62
Trieste	15,480	5,220	65
New York	15,500	9,400	40

The original capital of the company was two hundred million francs in four hundred thousand shares.

As subscribed for in November, 1858, they were distributed as follows:

France	207,000 shares.
Egypt	96,000 "
Austria	51,000 "
Russia	24,000 "
England	5,000 "
United States	5,000 "
Spain	4,000 "
Netherlands	2,000 "
All other countries	6,000 "
	400,000 shares.

The viceroy of Egypt now owns about 177,000 shares.

RECEIPTS OF THE SUEZ CANAL.

1st Quarter,	1867	255,149	francs.
2d "	"	262,752	"
3d "	"	300,321	"
4th "	"	474,597	"
1st "	1868	544,961	"

Mechanics, Physics, and Chemistry.

CORNISH PUMPING-ENGINES.

THIS class of engine is especially interesting on account of its superior economy of fuel. The conditions involved by which its pre-eminence, in this regard, has been attained, may be looked for in the following:

1. The high degree to which expansion may be advantageously employed.

2. The unfettered state of the piston, allowing celerity of action.

3. The saving of steam from loss by clearance, and steam passages.

4. The isolation of the working end of the steam cylinder from the cooling influence of the condenser.

5. The turning to direct account of the *vis viva* of the moving masses of the machine. Another source of economy is directly traceable to the use of the "Steam Jacket," an invariable adjunct to this class of engine.

Presuming that the reader is already acquainted with the peculiar construction of the Cornish pumping engine, and its manner of operation, the classified points of merit will next be reviewed. "The high degree to which expansion may be advantageously employed, in connection with the unfettered state of the piston, allowing celerity of action," is peculiarly adapted to the purpose of pumping water. Steam is admitted at the commencement of the stroke; up to the point of cut-off, the velocity of the weight is uniformly accelerated; the momentum acquired, together with the force given out by the expansion of the steam, carries the piston to the end of its stroke, when the resistance and pressure will coincide

In the out-stroke, the weight of the pump-plunger descends with a constant resistance, and consequently with a uniformly augmented velocity, and the momentum acquired is again stored up at the end of the stroke, in the steam contained above the piston, to be made available in the return stroke. Now, expansion, if carried to any considerable extent, necessitates the use of a high pressure of steam; its extended application, therefore, to a rotative pumping engine, is, strictly speaking, not admissible, owing to the varying speed given out by the steam expanding from a high initial pressure, to the low

degree at which the terminal pressure should be brought, having economy in view. This variation of pressure must be highly injurious, especially where the load is not susceptible of acquiring momentum, as is the case, to a considerable extent, in pumping water. From this, it will be seen, that a steam-engine designed for driving mill shafting, or other rotating machinery, where a uniform speed of revolution is necessary, would be entirely misapplied if put to pumping water. In the first case, a uniform speed of fly-wheel is indispensable, while in the latter a uniform speed of piston is required, extremes which never can be produced in connection. As a consequence, then, the fly-wheel must either govern the motion of the pump, or else the pump must govern the motion of the fly-wheel, and the latter, to be of any use at all, must be heavy enough to carry the engine over its centres, when running at a low rate of speed. In order to do this effectually, it must possess so much weight as invariably to make subsecutive, the primary object aimed at. It is true the employment of a heavy fly-wheel, counteracts to a certain extent, the varying pressure of the expanding steam; but the succession of shocks given out to the piston, by the admission of the steam, and its attenuated power at the end of the strokes, tells heavily upon the engine, in spite of the fly-wheel's modifying effect. And a tendency to break down can only be avoided by making the engine very heavy, and consequently expensive.

The evil effects of the irregular action of the pump plunger, can also be partially averted, by the use of a large air-vessel; a reservoir into which any excess of water delivered by the pump when working at its maximum velocity, is stored up to be given out again, when the pump is at its minimum speed, or passing its centres. The irregularities and internal struggles may be nicely smoothed over to the eye of the superficial observer, by the devices just described, but they will nevertheless exist to a damaging extent, and become manifest in due time in the matter of costly repairs, and heavy coal accounts.

We now pass to "the saving of steam from loss by clearance and steam passages, and the isolation of the working end of the steam cylinder from the cooling influence of the condenser." In the Cornish engine, that end of the steam cylinder where the steam is admitted from the boiler, never has any communication with the condenser. Steam being admitted at the commencement of the stroke, follows the piston up to the point of cut-off. The balance of the stroke is completed

by the combined aid of expansion, and the momentum acquired by the mass of material set in motion. The steam is then allowed to pass freely from one side of the piston to the other, producing an equilibrium of effect, during the out stroke. Before the piston arrives at the point of commencement again, the equilibrium valve is closed, shutting in a quantity of steam before it. It is evident that by means of this cushioning, the loss from clearance, and steam ports, is rendered practically nothing, if the steam so compressed be equal to the initial pressure. The piston is thus gradually brought to a neutral state at the end of the stroke, when the exhaust valve opens a communication between the *opposite side* of the cylinder, and the condenser *only*.

This is very different in all other descriptions of steam engines, where heat is abstracted at every single stroke from the metal of the cylinder, by the chilling influence of communication between it and the condenser, which lowering of temperature, must be raised again, at the expense of the entering steam. A certain quantity of heat passing thus, at each stroke, from the boiler, through the cylinder to the condenser, without contributing in any manner to the performance of work. And this effect is increased directly by a further liquefaction of the expanding steam, above that due to the loss by expansive working, the very presence of such an additional amount of condensation increasing at once the evil.

The next point to be considered, is "the turning to direct account of the *vis viva* of the moving masses of the machine." It would be paradoxical to suppose that more power could be given out by a moving weight, than the original force which created it. And it has been urged that nothing can be obtained from the momentum of the swinging masses of the beams, and heavy pump-tree, and balance-bob, more than a mere return of the force that started it in motion. Such an argument is perfectly valid. And all we claim for the Cornish engine is, that such a return is faithfully made, which is not the case with any other description of engine. One of the most important features in the Cornish engine, and on which depends its successful operation, is to proportion the gravity of the moving mass in strict accordance with the point at which the steam is to be cut off. A neglect of this invariable necessity, rendered the first Brooklyn pumping engine a complete and costly failure.

When the steam is first admitted to the piston, the force is much greater than is required to raise the heavy weight of the pump

plunger, consequently a very rapid motion is imparted, and the piston will be carried to the end of its stroke, by the acquired momentum. Although the pressure is not sufficient, near the end of the stroke, to balance its weight, the potential energy is gradually converted into actual work, until the end of the stroke, when it should be entirely exhausted, the terminal pressure will then just equal the load and back pressure. As a further proof of the advantage of a heavy moving mass, it has been found in practice, that "Bull Engines" are invariably inferior in duty to the beam variety, and that the latter description vary in their duty in proportion to the amount of metal distributed in the moving parts.

No such advantage as the above can accrue to the rotative engine; for whatever momentum the piston and its connections may possess at the end of the stroke, is entirely lost, being expended on the crank-pin, at the dead point, where no pressure whatever could produce any good effect.

Neither can any such results be obtained from the variety of direct acting steam pumping engines, from the simple fact that the steam cannot be used expansively to anything like the beneficial extent afforded by that principle. The terminal pressure must invariably be fully equal to the load, or the pump will come to a dead stand. It would be exceedingly difficult, in practice, to maintain the initial pressure precisely at a certain point. And in order not to fall below it, knowing the consequence, the disposition would be to carry an excess of steam above that necessary to perform the work; which excess of potential energy will be discharged at each stroke into the atmosphere, or condenser, the engine being high or low pressure. The last feature of presented economy, is to be found in the use of the "steam jacket," a casing of cast iron, enveloping the steam cylinder, having an annular space between the two of about one inch, which space is constantly supplied with steam from the boilers, maintaining the temperature of the metal of the cylinder to an extent preventing the liquefaction of the steam working expansively within the cylinder.

When work is done by expansion, heat must necessarily disappear and manifest itself in a fall of temperature, producing liquefaction; the rate of expansion being duly accompanied by a corresponding fall of temperature. Steam becomes liquid in a naked cylinder, simply by the heat passing off to the outside air, and the effect is indirectly increased by the extent of saturation produced

in expansive working, as moist steam being a better conductor of heat than dry, parts with its heat more rapidly to any neighboring conducting material of a lower temperature. It is not by the addition of a steam jacket that the evil of condensation, attendant upon the rate of expansion, can be averted, as this will necessarily take place from the constancy of natural laws; but the liquefaction will take place in the steam jacket, instead of the cylinder, with entirely different results. Condensation in the former case can do no serious harm; for instead of being lost in the condenser, and carrying off heat, it is returned to the boilers by a return pipe, proceeding from the bottom of the jacket.

From the results of extended practical observation of the duty developed by the various descriptions of English pumping engines, the Cornish stands pre-eminent for its remarkable economy; the duty in one case, having amounted to 130,000,000 pounds of water raised one foot high by 112 pounds of coal. Future developments looking to an increased rate of economy, may be looked for in the possible adaptation of the compound principle applied to the Cornish type.

W. M. HENDERSON,
Hydraulic Engineer.

Philadelphia, May 9th, 1868.

PATENTING A PRINCIPLE.

(Concluded from page 414.)

It is unnecessary to go through all the cases in the English books to which this explanation applies. One, which was determined by our own Supreme Court, deserves to be noticed here, especially because it was considered at the same term with O'Reilly *v.* Morse, and both must have been together in the minds of the judges—that of Winans *v.* Dennacad, 15 How. 330. The plaintiff's invention consisted in constructing coal-cars in the form of the frustum of a cone. The defendant's cars were octagonal instead of circular, but otherwise resembled the plaintiff's. One of the judges inclined to the opinion that the plaintiff was, by the terms of his patent, limited to the precise form he had described, and could have no remedy against others who used a different one. It was shown that there was no practical difference between the two; but either

would derive especial strength from the mechanical law involved. And, though the plaintiff's claim was, in express terms, to the frustum of a cone; though he did not pretend to claim the mechanical law thus applied, the defendant was held to have violated his patent. This could not be on the ground that the principle of mechanics was patented. It must have been on the ground that the form adopted by the defendants was a mere equivalent for that of the plaintiff.

It may be said that what have been designated as mechanical laws in the preceding pages, are in truth laws of nature, physical just as much as the properties of matter, and that the two classes run into each other, so that no distinction can be made between them. It is not necessary to insist that there may be in theory. In practice, there is a radical difference which fully justifies their being considered as belonging to two classes. In the case of inventions founded on what have been termed mechanical principles, the patentee obtains full protection in the exclusive enjoyment of the principle by being allowed an action against every one who uses an equivalent for his device. No machine can be constructed on the principle of his which does not embrace such equivalents. It may not be so where the novelty of the invention consists in some property of matter first brought to light by the patentee. Neilson's patent covered the use of a vessel for heating air placed between the blower and the furnace—not the introduction of heated air into the furnace, which was truly his discovery. If any one could have contrived to heat the air sufficiently before it entered the blower, he might have availed himself of Neilson's discovery with impunity. The difficulty of doing this constituted the whole strength of his patent. Anybody might have availed himself of the quality of lead discovered by the Tathams, if he could have got up a machine of a different construction. It is very possible that the courts may give a larger range to the doctrine of equivalents, in order to secure to the discoverer of a new physical property an adequate reward for his ingenuity. Thus far, it is only as the defendant has been found to have employed mechanical equivalents for the construction specified by the patentee, that he has been held guilty of infringement, or the patentee has obtained protection.

There are a few other cases upon this subject which are not open to the explanation given to those heretofore mentioned, and which may be thought to require a passing notice.

The plaintiff in Forsyth *v.* Riviere, 1 W. P. C. 97, after describing in his specification the explosive compounds employed by him in igniting the charge in fire-arms, added: "I do not lay claim to the invention of any of the said compounds," &c., "my invention in regard thereto being confined to the use and application thereof to the purposes of artillery and fire-arms as aforesaid. And the manner of priming and exploding which I use is," &c., proceeding to describe it. There was no specification of claim. It is manifest that this patent was for the method he employed. It is true that the reporter says the defendant's lock was constructed differently; but he does not furnish the slightest intimation in what respect it varied. The note of the case is very short and unsatisfactory. The report, bearing the same title in Chit. Pr. C. 182, is upon another point entirely. But from the statement of the counsel in Minter *v.* Wells, W. P. C. 128, we learn that all the difference between the locks was this: in the patentee's the hammer struck the pan containing the composition, and in the defendant's the pan struck the hammer.

No one can read the patent of the plaintiff in Hall *v.* Boot, 1 W. P. C. 100, without perceiving that he laid claim to his machinery when used in connection with gas flame. There was no positive evidence what machinery the defendants used, it is true; but this does not warrant the inference that the court recognized the plaintiff's title to the exclusive use of gas flame with any machinery for the same purpose. There was circumstantial proof of the strongest kind that the defendant's was borrowed from the plaintiff's, and was identical with it.

The claim set up in Booth *v.* Kennard, 1 Hurls. & N. 527, was for "making gas direct from seeds and matters herein named for practical illumination, or other useful purposes, instead of making it from oils, resins, or gums previously extracted from such substances." Upon the trial of the case, POLLOCK, C. B., held this claim to be too broad, and directed a verdict for the defendant. The verdict was set aside in the Court of Exchequer Chamber; and from the report it would certainly seem as if the court considered the patent valid. But when the cause came on for trial again before Chief Baron POLLOCK, he said that the court had decided nothing more than this: that the invention "was one which, if new, might be patented if properly specified." He added, "we are also of opinion that the claim is too large, and that such claim cannot be

supported." There was a verdict for the defendant again. But as there was also strong evidence upon that trial that the invention was not new, the plaintiff probably deemed it unsafe to proceed any further, after moving that a verdict should be entered up for him, and being denied. Little or no reliance is manifestly to be placed on the report of the decision in the Exchequer Chamber, after the explanation given by Chief Baron POLLOCK.

The plaintiff in Seed *v.* Higgins, 8 Ell. & Bl. 755, 771, and 6 Jur. N. S. 1264, had originally taken out a patent for the application of the law or principle of centrifugal force to the particular or special purpose above set forth;" *i. e.* to fliers used for preparing, slubbing, or roving cotton, &c., so as to produce a hard and evenly compressed bobbin. He afterwards discovered that centrifugal force had been employed already for the same purpose, though by different means; and he therefore filed a disclaimer, by which he limited himself to the mechanism he had described in his specification. Upon this a a question arose whether his patent did not, when thus amended, appropriate a different invention from anything embraced in his original specification, and was not therefore void. The case was very fully discussed in several courts, but was finally decided against the plaintiff upon the ground that the defendant's machine was no infringement of the patent. In the course of delivering their opinions it was incidentally mentioned by one or more of the judges, that the defendant's machine came within the purview of the patent as originally framed. But there was no opinion expressed throughout as to the validity of the original patent, nor any allusion made to the subject. If it may be inferred from the silence observed respecting it that the validity of the instrument was admitted, there is some propriety in referring to the case when examining this doctrine. It will probably be regarded by most as of no weight whatever.

The court interpreted the second claim made by the plaintiff, in Bovill *v.* Keyworth, 7 Ell. & Bl. 724, to be for "exhausting the air from the cases of the millstones, combined with the application of a blast to the grinding surfaces." Upon this, Lord CAMPBELL, who presided, remarked as follows, viz.: "Still if the specification does not point out the mode by which this part of the process (No. 2) is to be conducted, so as to accomplish the object in view, it would be a statement of a principle, and the patent would be invalid." He held it to be sufficient, however. And it may well be doubted

whether it was fairly open to the objection that it would have been for a principle without a description of the process, though such a description was no doubt essential. The case belongs to a class which has been often supposed to involve the legality of patenting a principle, but really has little to do with it. A blast and an exhaust are two mechanical forces as well known as a stream of water or as steam. Every artisan skilled in the business is perfectly familiar with them, and knows how to produce them. The invention in this instance consisted in combining the two so as to produce a particular effect. After describing how this might be done, the specification defines the invention as consisting in the combination of these two forces, each applied to a particular and well known mechanism. In all this we see nothing like patenting a principle, and apprehend there was no foundation for the remark of his Lordship. He may have had an idea that the patent would have been defective in not specifying some visible structure as the invention; but that is very different from patenting a principle. The case has little or no bearing on that subject.

From this discussion and examination of the cases the following conclusions are legitimately drawn:

1. Every discoverer of a new and useful application of any law of nature, any quality of matter, or any mathematical principle, is entitled to a patent for it.

2. It is not necessary to entitle him to a patent, that he should have been the first to search out and make known the law, quality, or principle which he has thus applied. And his having been the first to bring it to light adds nothing to his claims.

3. He will be protected in his right by holding as infringements of his patent all mechanical equivalents for the devices for carrying his discovery into effect, which he has described and designated in his specification as his invention. And he can have no other protection, even though the principle he has applied was first discovered by him.

4. No one can legally specify as his invention, and take out a patent for the exclusive use of any such law, quality, or principle when employed for the same purpose as his. No instance can be found where any such patent has been sustained, and they have been repeatedly pronounced invalid by the courts.

S. H. H.

NITRO-GLYCERINE: ITS CLAIMS AS A NEW INDUSTRIAL AGENT.

By John Mayer, F. C. S.

Notwithstanding the lamentable occurrence at Newcastle, in December last, resulting, as it did, in the death of seven persons, and notwithstanding the fact, likewise, that nitro-glycerine has in three or four instances, in America, proved itself to be a dangerous compound when not properly dealt with, its advantages as a blasting agent have been so extensively and so satisfactorily demonstrated, during the last three years or so, that it is high time that industry should more generally step in and claim it as a new handmaid which science has placed within her reach. Already on the continent of Europe, and in America, this remarkable compound has established its claim to rank in the first place as an explosive agent; and it is the object of the present article to examine in a scientific and dispassionate manner its title to be regarded in that light, in such a manner, indeed, as shall, we hope, form a marked contrast to the wild panic-stricken editorials which were so numerous in the daily and weekly newspapers during the latter half of the month of December last. There would have been less need for this present "corrective," if certain scientific journals had not also run riot immediately after the Newcastle explosion, instead of showing that their guiding minds were possessed of the spirit of true scientific acumen and a desire to aid industrial progress in the fullest sense of that term.

It is not undesirable to refer, although very briefly, to the history and manufacture of nitro-glycerine, so as to carry our readers along with us intelligibly to the conclusion of our remarks.

Nitro-glycerine has been known as a blasting material in the operations of mining, quarrying, and railway-cutting, for about three years; but it is fully twenty years since it was discovered by a young Italian, M. Ascagne Sobrero, while he was a student in the laboratory of the well known French chemist, Pelouze. Briefly, it may be stated that Sobrero obtained it as a result of the action of a mixture of strong nitric and sulphuric acids on glycerine. He examined it somewhat minutely, as also did several other chemists, continental and British. Amongst them Dr. J. H. Gladstone is not unworthy of mention. He reported at considerable length regarding it to the Chemical Section at the Cheltenham Meeting of the British Association.*

In course of time many facts were noted with reference to its true chemical nature and its chemical and physical properties, the chief of which, of course, was its great explosiveness, or rather its great power as an explosive compound. The practical utilization of this property was left for Mr. Alfred Nobel, a Swedish mining engineer.

* British Association Reports, 1856.

He was quick enough to observe that it might possibly be used in mining operations, and scientific enough to discover how it could be manufactured on the large scale, chemically pure, and always of the same quality in every respect. Former observers had been much troubled with it, owing to its instability, its tendency to decompose spontaneously, and generally with explosive violence. All chemists who know anything of the early history of gun-cotton will remember that chemical instability and spontaneous decomposition were almost invariably associated with it. Some French chemists still regard it as a very unstable, and, therefore, unsafe substance; but Von Lenk and Professor Abel have amply demonstrated that, if thoroughly cleansed raw cotton be used and every trace of acid be removed from the manufactured product, the tendency of gun-cotton to spontaneous decomposition is completely overcome. Nobel did exactly the same for nitro-glycerine, and its manufacture soon became in his hands one of the practical arts. He secured patent rights for his process of manufacture in most European states, and himself settled down on the Elbe, in the vicinity of the city of Hamburg, as a manufacturer of the new explosive, or "blasting oil," as he chose to call it.

There are now five establishments in existence—collectively aged eleven years—where nitro-glycerine is manufactured on the large scale. They are at Lauenburg (Prussia), the one just referred to as outside the city of Hamburg, at Stockholm, Christiana, Helsinfors, and New York. In order to reduce to a minimum the danger which is alleged to attend the manufacturing operations, the establishment first mentioned is wholly built in an artificial excavation in and beneath the level of the earth; and thus any explosion which may possibly result in the works will be confined to the works themselves, and will exert no damage in a lateral direction. This plan might well be adopted in building gun-powder mills. As an indication that the manufacture of nitro-glycerine is conducted on an exact system, on rigidly scientific principles, it may be mentioned that in only one instance has there been an explosion in any of the five works mentioned, and even that was but a very slight one. The manufacture has not yet been introduced into England, although we carry on mining operations, quarrying, railway-tunnelling, &c., on such a stupendous scale as is not excelled in any country of similar extent. Why English capitalists have not taken to it we know not; but of this we feel assured, from what we know of the extent to which nitro-glycerine is already in use amongst us, that the manufacture of this substance is yet destined to become a profitable undertaking in this country, when its use will doubtless be very greatly extended.

As might almost be inferred from the name, and, indeed, as has already been mentioned, nitro-glycerine results from the action of nitric acid on glycerine; at all events, the chemistry of the opera-

tion is essentially limited to the reaction of those two substances on each other. In practice, it is found necessary to use sulphuric acid in conjunction with the nitric acid, as in the production of gun-cotton. The essential details of the chemical transformation are the following, according to M. Kopp and various other chemists:—Fuming nitric acid (sp. gr. about 1·52) is mixed with twice its weight of the strongest sulphuric acid, in a vessel which is kept cool by being surrounded with cold water. When this acid mixture is properly cooled, there is slowly poured into it rather more than one-sixth of its weight of syrupy glycerine; constant stirring is kept up during the addition of the glycerine, and the vessel containing the mixture is maintained at as low a temperature as possible by means of a surrounding of cold water, ice, or some freezing mixture. It is necessary to avoid any sensible heating of the mixture, otherwise the glycerine is to a large extent transformed into oxalic acid. When the action ceases, nitro-glycerine is produced. It forms on the surface as an oily-looking fluid, the undecomposed sulphuric acid forming the subjacent layer, owing to its greater specific gravity. The whole mixture is then poured, with constant stirring, into a large quantity of cold water, when the relative specific gravities become so altered that the nitro-glycerine subsides and the diluted acid rises to the surface. After the separation in this manner into two layers is effected, the upper layer may be removed by the process of decantation or by means of a siphon, and the remaining nitro-glycerine is washed and re-washed with fresh water till not a trace of acid reaction is indicated by blue litmus paper. The final purifying process pursued by Mr. Nobel,* is to crystallize the nitro-glycerine from its solution in wood naphtha. Every chemist knows that by this means the substance will be chemically pure and of uniform composition and quality.

Before enlarging on the properties of nitro-glycerine and its applications, we may just glance at its chemical nature for a moment or two. Glycerine is a ternary compound, a sort of oxidized hydrocarbon, its formula in the ordinary notation being $C_6 H_8 O_6$. The combined action of the strong sulphuric and nitric acids is to transform it into a quaternary compound, a substitution product, in which three equivalents of peroxide of nitrogen ($3 NO_4$) are substituted for three equivalents of hydrogen, which are removed during the reaction. The chemical constitution of nitro-glycerine may therefore be indicated in the following manner:—

$$C_6 \left\{ \begin{matrix} H_5 \\ (NO_4)_3 \end{matrix} \right\} O_6, \text{ or } C_6 H_5 (NO_4)_3 O_6.\dagger$$

As a substitution-product, or *nitro-compound*, nitro-glycerine very

* Letter in "The Times," 27th December, 1867.

† Mr. Nobel regards nitro-glycerine as having the following composition (ordinary notation):—$C_6 H_5 O_3 (NO_5)_3$, and alleges as a reason, that a solution of caustic potash will decompose the nitro-glycerine, resolving it into glycerine and nitric acid, and, with the latter, forming nitrate of potash.

much resembles gun-cotton, the *nitro-cellulose* of the chemist; indeed, it may almost be regarded as liquid gun-cotton; and certainly it has a great amount of interest for the scientific chemist, as much even as for the practical man who employs it as an industrial agent.

As prepared in the manner already mentioned, nitro-glycerine is an oily looking liquid, of a faint yellow color, perfectly inodorous, and possessed of a sweet, aromatic, and somewhat piquant taste. It is poisonous, small doses of it producing headache, which may also be produced if the substance is absorbed into the blood through the skin, and hence it is not desirable to allow it to remain long in contact with the skin, but rather to wash it off as soon as possible with soap and water. Glycerine has a specific gravity of about 1·25–1·26, but the nitro-glycerine has a specific gravity of almost 1·6, so that it is a heavy liquid. It is practically insoluble in water, but it readily dissolves in ether, in ordinary vinic alcohol, and in methylic alcohol or wood spirit. If it be simply exposed to contact with fire it does not explode, although it is so powerful as an explosive. A burning match may be introduced into it without producing any explosion; the match may be made to ignite the liquid, but combustion will cease as soon as the match ceases to burn. Nitro-glycerine may even be burned by means of a cotton-wick or a strip of bibulous paper, as oil from a lamp, and as harmlessly. It remains fixed and perfectly unchanged at 212° Fah.; if heated to about 360°, however, it explodes. Kopp says that it may be volatilized by a regulated heat without decomposition, but if it boils, detonation becomes imminent, and hence, when it is dropped on a metal plate which is hot enough to cause it to boil it will decompose with a somewhat violent detonation. A plate not actually red-hot will cause this change; if, however, the plate be red-hot, a drop of nitro-glycerine falling on it will immediately take fire and burn like a grain of gunpowder. At temperatures below from 43° to 45° Fah., it becomes a glassy crystalline mass, but is otherwise unchanged. It was crystallized nitro-glycerine which exploded on the Town Moor of Newcastle. Notwithstanding the great quantity of oxygen which is contained in this substance, and the powerful affinity which phosphorous and potassium have for that element, they have no effect on nitro-glycerine. If prepared perfectly pure, it is totally devoid of any tendency to volatilize, and it may be kept for an indefinite period of time without showing any proneness to spontaneous decomposition.

Nitro-glycerine may be decomposed with the greatest of ease by treatment with caustic potash, which resolves it into glycerine and nitric acid. This is certainly the most effectual means of rendering it permanently harmless, although there are other substances which will bring about its decomposition without any explosion. The extraordinary power exerted by nitro-glycerine during its explosion is undoubtedly the most interesting property which this substance possesses. The practical utilization of this explosive power

was at first thought impossible, because it was observed that a spark would not produce any explosion at all, and that a blow from a hammer or some similar instrument would only produce a detonation that was limited exclusively to the part struck. In using all other ordinary explosives, such as gunpowder and gun-cotton, it is practically necessary to employ fire, either as a spark or a flame, and as this would be of no use in the case of nitro-glycerine, some other mode of exploding it had to be resorted to. Mr. Nobel, who was the first person to demonstrate the possibility of using nitro-glycerine as a new industrial agent, hit upon the method now universally adopted, namely, percussion, or rather concussion. When a quantity of nitro-glycerine is spread in a thin layer over the surface of a hard stone, an anvil, or other metallic mass, and then *percussed*, or sharply struck with a hammer, only that portion actually struck explodes or detonates, so that percussion pure and simple is practically useless. The whole mass of explosive liquid must be violently *concussed*, and to produce the required concussion, the nitro-glycerine must be in a confined space, while, immersed in the liquid, there must be a small bag of gunpowder, or a percussion cap of extra strength, firmly fixed on the end of a gunpowder fuse. Thus it will be seen that nitro-glycerine almost requires to be coaxed into an explosive mood; and if people could only be brought to look on the explosions at Newcastle, San Francisco, Aspinwall, and one or two other places, without prejudice, it would universally be admitted that nitro-glycerine is not only not that frightfully dangerous material which many people in their ignorance believe it to be, and which some of them in a panic-stricken mood propose to "stamp out," but that it is even less dangerous than gun-cotton and gunpowder, and more completely under control than they are. We know that this is a very heretical and unorthodox utterance, still it is one that can be most indisputably supported and established by a great accumulation of facts resulting from the observations and experience of many persons whose minds are perfectly unbiassed.

Taking advantage of the circumstance that nitro-glycerine is soluble in wood spirit or methyl-alcohol, Mr. Nobel, nearly two years ago, made the happy discovery that it could almost instantaneously be rendered inexplosive, and that its explosiveness could be restored to it with equal readiness. The method of making it inexplosive is at once simple and effective. It is to mix with it from five to ten per cent. of wood spirit, when all attempts at exploding it are rendered utterly futile. Five per cent. of methyl-alcohol is said to be amply sufficient to transform the nitro-glycerine into the inexplosive or protected state, but Mr. Nobel now always adds ten per cent. before sending any of his blasting liquid into the market. A commission, appointed by the Hamburg Association for the Promotion of Arts and Useful Professions, made an extensive series of experiments on nitro-glycerine protected by the addition of

five per cent. of methyl-alcohol, in October, 1866. One of the experiments was an attempt to explode the liquid in the ordinary way with fuse and percussion cap. The experiment was twice repeated, but in neither case did the detonation of the cap affect the liquid. In another instance the protected liquid, in a tin bottle, was fired at with a bullet, but it was found impossible to produce an explosion. "In the opinion of the commissioners," the official report concludes, the protected blasting liquid "is perfectly inexplosive." When this protected liquid is exposed to heat in a proper vessel, the volatile solvent escapes, and in course of time, under the influence of a high temperature, the nitro-glycerine explodes, but not with the usual amount of violence, because, probably the explosion occurs before all the methyl-alcohol volatilizes. If protected nitro-glycerine be spread over the surface of an anvil, and then struck with a hammer in the usual way, it will not explode; after the lapse of some time, however, the explosive state is induced, owing to the evaporation of the solvent liquid.

(To be continued.)

LECTURE-NOTES ON PHYSICS.

By Prof. Alfred M. Mayer, Ph.D.

(Continued from page 405.)

9. *Inertia—Force.*

The property of matter by which it tends to retain its state, whether of rest or of motion, is called inertia.

By saying that a body has inertia, we merely understand that a body cannot *of itself* modify its condition, whether of rest or of motion; and that whenever a body begins to move, or to change the velocity or the direction of its motion, these changes in its condition are to be referred to some extraneous cause.

When a body is set in motion and abandoned entirely to itself—when it is conceived as being alone in space—it will move in *a straight line*, which is the direction of its first motion, and with its first velocity forever. This truth, called the law of inertia, is the result of an extended induction, and was not recognized before the time of Kepler. Descartes made it the foundation of his principles of mechanics.

Give illustrations of above principle, from observations of the motions of the heavenly bodies, and from experiments on the motions of bodies on the surface of the earth. The rotation of the

earth on its axis. A pendulum will vibrate two days in a vacuum, when the friction of the point of suspension is reduced to its minimum.

The apparent departures from the law of inertia, can all be referred to the action of forces or of resistances exterior to the body, and which are opposed to its uniform motion in a straight line.

Force.

All the phenomena, or changes which we observe in the condition of matter, are motions or the results of motions of either masses or of their ultimate parts or atoms; and that which produces these changes in the condition of matter is denominated *force*.

To Dr. Julius Robert Mayer, of Heilbronn, Germany, we owe the first successful attempt to give as clear conceptions in reference to force, as previously existed in relation to matter. In 1842, he published in *Liebig's Annalen*, a short paper of eight pages, entitled *Bemerkungen über die Kräfte der unbelebeten Natur*, which from the fundamental importance of the truths which it unfolds, and from the results which have been deduced from them, is to be considered as one of the most important additions to knowledge produced in this century.

Mayer reasons thus: "Forces are causes; accordingly, we may in relation to them, make full application of the principle, *causa, æquat effectum*. If the cause c has the effect e, then $c = e$; if, in its turn, e is the cause of a second effect, f, we have $e = f$, and so on; $c = e = f \ldots . = c$. In a chain of causes and effects, a term or a part of a term can never, as plainly appears from the nature of an equation, become equal to nothing. This first property of all causes we call their *indestructibility*.

"If the given cause, c, has produced an effect, e, equal to itself, it has in that very act ceased to be; c has become e; if, after the production of e, c still remained in whole or in part, there must be still further effects corresponding to this remaining cause; the total effect of c would thus be $> e$, which would be contrary to the supposition $c = e$. Accordingly, since c becomes e, and e becomes f, &c., we must regard these various magnitudes as different forms under which one and the same object makes its appearance. This capability of assuming various forms, is the second essential property of all causes. Taking both properties together, we may say causes are (quantitatively) *indestructible* and (qualitatively) *convertible* objects."

In another important paper, "*Bemerkungen über das mechanische Aequivalent der Wärme*, 1851," Mayer says: "*Force is something which is expended in producing motion;* and this something which is expended is to be looked upon as a cause equivalent to the effect, namely, to the motion produced."

Now, in these motions or effects, there are evidently two things to be considered, (1) the *mass* of matter moved, and (2) the *space* through which it is moved; and we have therefore force = mass × space gone through; but as we can *measure* and *compare* forces only by measuring and comparing their effects, and as bodies in free motion will move in the same right line, and with uniform velocity forever, we must place the moving bodies in such circumstances that their motions are destroyed, and we have remaining in their stead, equivalent effects, which we can *measure;* then the comparison of these measures will give us the relative intensities of the forces.

These effects, either directly or indirectly obtained from the moving body, are as various as there are kind of forces and resistances existing; thus, we may oppose to a body, moving vertically upward, the resistance of gravity (which we may regard as constant, if the upward flight of the body is a very minute fraction of the radius of the earth); or, we may oppose the constant resistance, which a body of homogeneous structure offers when it is penetrated by another, as, for example, when a cannon ball penetrates earth, clay, or pine wood; or, again, we may have, for the effect of the destroyed motion, *heat*, which makes its appearance whenever a moving body is brought to rest either by friction, percussion, compression, &c., with some other body, or, as in Foucault's experiment, where a copper disk being forced to revolve between the poles of a powerful electro-magnet, the motion of the wheel being opposed by the reaction existing between the electric currents flowing in it and in the magnet, the motion (force) lost by the wheel appears as heat (force) in its substance.

The heat which is produced by any of these means can readily be caused to evolve, as *it* disappears, dynamic electricity, light, and chemical action. Thus, in an experiment which the author devised for his classes, about four years ago, the *heat* developed by the "*falling force*" of a weight striking the terminals of a compound thermal-battery, formed of pieces of iron wire and German silver wire twisted together at alternate ends, caused a current of electricity through

the wires, which being conducted through a helix *magnetized* a a needle (which then attracted fine iron particles), caused *light* to appear in a portion of the circuit formed of Wollaston's fine wire, *decomposed* iodide of potassium, and finally *moved* the needles of a galvanometer.

Let us now try to arrive at comparable measures of force by first opposing to the moving body the constant resistance of gravity, and see if the measures thus given for different velocities compare with measures given by other resistances overcome, and for different quantities of heat, electricity, &c., developed by the disappearance of different velocities in the moving mass.

A body, shot vertically upward, with a velocity v, comes to rest, by the opposing resistance of gravity, after having reached a certain height, which we will call h. Giving the body twice the initial velocity, $2v$, it reaches $4h$ before it begins to return to the earth; with the initial velocity $3v$, it reaches the height $9h$; while $4v$ gives $16h$, and so on; in other words, *the heights reached are as the squares of the initial velocities.*

Wherefore, as force = mass × space gone through, it follows that the measure of force is *mass* × v^2; v being the velocity of the mass; or, *force* = *mass* × *distance gone through* in overcoming the constant resistance = *mass* × v^2.

If this measure be true, the same ratio of the square of the velocity, will exist when other resistances are opposed to the moving body. Take the resistance offered by an earth or clay bank to the penetration of cannon balls having different velocities. It is found by artillerists, that a ball striking with the velocity $2v$, will penetrate four times as deep as the same ball with velocity v; while a velocity of $3v$ will give a penetration of nine times the depth and so on; the penetration of the same ball being as the squares of its velocities. (See Dr. Wollaston's Bakerian Lecture on the Force of Percussion, Phil. Trans. 1806; and Benton's Ordnance and Gunnery, N. Y., 1862, p. 476, *et seq.*)

Having found this measure of force true for these two cases, where motion disappears, let us determine, as we only can, *experimentally* and *inductively*, whether the relative quantities of *heat* evolved as different velocities of the moving mass disappear, also preserve the ratio of the squares of those velocities.

In the year 1850, there appeared in the Phil. Trans. R. S. Lond., a paper "*On the Mechanical Equivalent of Heat*," by Dr. James

Prescott Joule, of Manchester, England. This memoir contains one of the most important physical constants ever determined.

In this investigation was first obtained, *by direct experiment*, the exact quantity of heat developed by the falling of a given weight through a known height. His experiments on this subject began in 1843, and were continued during six years, until 1849. Dr. Joule, during this long experimental experience, gradually perfected his apparatus, and learned to eliminate various sources of error, until finally his measures arrived at by different processes gave, within small limits, almost identical values for "the mechanical equivalent of heat."*

His apparatus consisted of an upright copper cylinder, which contained either water, oil, or mercury; in the lid of this vessel were two apertures, one for a vertical axis, to revolve in without touching the lid, the other for the introduction of a thermometer. The vertical axis, which was perfectly fitted into the bottom of the vessel, carried eight revolving arms or paddles, which, as they went round, passed between openings in four stationary vanes, so that the water could not acquire a motion of rotation and move with the arms; and resistance was thus made to their motion. Two weights were attached to fine flexible cords, which passed over pulleys, and were wound round a roller on the vertical axis, armed with the paddles. These weights in falling caused the paddles to revolve, and by the resistance which it opposed to their motion, the liquid was heated by the equivalent in motion expended. The height of the fall was about sixty-three feet (to which we may say that practically the radius of the earth was infinite), and was measured by vertical scales, along which the weights descended.

The mode of experimenting was as follows: the temperature of the liquid having been ascertained by a thermometer, which was capable of indicating a variation of temperature as small as $\frac{1}{200}$th of a degree Fah., and the weights wound up by detaching the roller from the vertical paddle-axis, the precise height of the weights were ascertained after keying the roller; the weights then descended until they reached the floor. The roller was again detached from the

* It is to be remarked that Mayer, in 1842, used the expression "mechanical equivalent of heat," and from the difference in the specific heats of the same weight of air under constant pressure, and under constant volume, theoretically *deduced* a value for this equivalent, which, corrected with the exact data of the above quantities as furnished by Regnault, gives a result nearly identical with Joule's.

paddle-axis, the weights wound up, and the agitation of the liquid renewed. This was repeated twenty times, and then the temperature of the liquid was again observed. The mean temperature of the room was derived from observations made at the beginning, middle, and end of each experiment.

Corrections were now made for the effects of radiation and conduction; and, in the experiments with water, for the quantities of heat absorbed by the copper vessel and by the paddle wheel. In the experiments on the heat produced by the agitation of mercury, and in the heat given out by the rubbing of cast iron plates, the heat capacity of the entire apparatus was ascertained by observing the heating which it produced on a known weight of water in which it was immersed. In all the experiments, corrections were also made for the velocity with which the weights came to the ground, and for the rigidity of the strings. The force expended in friction of the apparatus was diminished as far as possible by the use of friction wheels, and its amount was determined by connecting the pulleys without connection with the paddle-axis, and ascertaining the weight necessary to give them a uniform motion.

The following table gives the results of Joule; the second column, as they were obtained in air, the third, the same corrected, as though the weights had descended in vacuo.

MATERIALS EMPLOYED.	MEAN EQUIV. IN AIR.	MEAN EQUIV. IN VAC.	NO. OF EXP'S FROM WHICH DERIVED.
Water	773·640	772·692	40
Mercury	775·032	774·083	50
Cast Iron	775·938	774·987	20

In the experiments of producing heat by the rotation of one cast iron plate on another, the friction produced considerable vibration in the frame work of the apparatus, and a loud sound; allowance was therefore made for the quantity of force expended in producing these effects.

The number 772·692, obtained as the mean of forty experiments on the friction of water, Joule considered the most trustworthy; but this he reduced to 772, because, even in the friction of liquids,

he found it impossible entirely to avoid vibration and sound. The deductions of Joule from these experiments are :

1. *That the quantity of heat produced by the friction of bodies, whether solid or liquid, is always proportional to the force expended.*

2. *That the quantity of heat capable of increasing the temperature of one pound of water (weighed in vacuo, and between* 55° *and* 60°) *by* 1° *Fah., requires for its evolution the expenditure of a mechanical force represented by the fall of* 1 *pound through* 772 *feet, or* 772 *foot-pounds.*

This is the "*Mechanical Equivalent of Heat*," or the unit of heat, generally called in honor of the illustrious physicist, "Joule's Unit."

In French measures, the above heat-unit is thus stated: *The heat capable of increasing the temperature of* 1 *kilogramme of water* 1° *C., is equivalent to a force represented by the fall of* 423·55 *kilogrammes, through the space of* 1 *mêtre.* The descent or ascent of 1 pound through 1 foot is called *a foot-pound*, while the descent or ascent of 1 kilogramme through 1 mêtre is denominated a *kilogramme-mêtre.* By the adoption of these terms, the expressions of the above truths can be mere concisely enunciated; thus, using French measures, we say, 423 *kilogramme-mêtres is equivalent to* 1 *kilogramme-degree centigrade.*

Thus, Joule showed that the heat developed was in proportion to the mass × the distance fallen through; or, what is the same, equivalent to the mass × square of the velocity.

In a remarkably interesting paper, "*On the Production of Thermo-Electric Currents by Percussion*," Prof. O. N. Rood, of Columbia College, N. Y., shows directly by careful and skilful experiments, that the heat and its equivalent in dynamic electricity (which latter gave the measure of the heat), produced by a weight falling from different heights on a compound plate of German silver and iron, was in proportion to the height of the fall of the weight, or, what is the same, to the square of the velocity of impact.

For the details of these experiments, and the precautions taken to avoid the action of extraneous causes mingling themselves with the main effect, the reader is referred to Prof Rood's paper in "The American Journal of Science, July, 1866."

We here only give some of the results, which speak for themselves.

Table 2.—With Two Skins Above and Below Junction of Metals.				
Distances fallen by Weight	1 in.	2 ins.	3 ins.	4 ins.
Deflection of Galvanometer-needles —Average of eight Observations	1°·3	2°·7	3°·55	5·°2

Table 3.—With Four Layers of Plain Silk Above and Below the Juncture.				
Distances Fallen	1 in.	2 ins.	3 ins.	4 ins.
Average Deviation of eight exp'ts.	1°·5	3°·0	4°·5	6°·0

Table 5.—With Four Layers of Wax-Coated Woven Silk.					
Distances Fallen	1 in.	2 ins.	3 ins.	4 ins.	5 ins.
Reduced Average Deviation of Five Experiments	1°·07	2°·1	3°·28	4°·3	6°·0

For a proper interpretation of the above results, it is to be remarked that the deflection of the galvanometer needles up to 6° was in proportion to the intensity of the current, which is itself, within these limits, proportional to the heat at the juncture which developed it.

It can be further shown that the measure of force, or *energy* (a term now more generally used, and which we owe to Dr. Thomas Young), is proportional to the square of the velocity of a moving mass, by obtaining the equivalents of effects other than those of resistance offered by gravity, by penetrable bodies, and of the heat developed by friction and by impact. Joule, in 1843, showed that the same relation existed between the heat evolved by the electric current of an electro-magnetic engine, and the mechanical energy expended in producing it, and in 1844 he showed that the heat absorbed and evolved by the rarefaction and condensation of air, is proportional to the amount of mechanical energy evolved and absorbed in these operations.

In the following table, taken from Verdet's "*Exposé de la Théorie Méchanique de la Chaleur*," *Paris*, 1863, are given the most reliable determinations of the mechanical equivalent of heat. The numbers represent the number of kilogramme-mêtres, which is equivalent to one kilogramme-degree centigrade of water.

NATURE OF THE PHENOMENON WHENCE THE DETERMINATION IS DRAWN.	PHILOSOPHERS WHO HAVE INVENTED THE THEORETICAL PRINCIPLES OF THE DETERMINATION.	PHILOSOPHERS WHO HAVE SUPPLIED THE EXPERIMENTAL DATA.	MECHANICAL EQUIVALENT.
General Properties of Air.....	Mayer Clausius	V. Regnault, Moll & Van Beek	426
		Joule	424
Friction.....	Joule	Favre	413
Work done by the Steam Engine	Clausius	Hirn	413
Heat evolved by Induced Currents	Joule	Joule	452
Heat evolved by an Electro-Magnetic Engine at Rest and in Motion.....	Favre	Favre	443
Total Heat evolved in the circuit of a Daniell's Battery...	Bosscha	W. Weber Joule	420
Heat evolved in a metallic wire, through which an electric current is passing.....	Clausius	Quintus Icilius	400

From the above discussion, we conclude that the true measure of force is $mass \times v^2$.

(To be continued.)

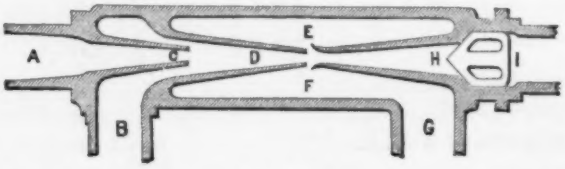
THE PROPOSED PORTLAND AND RUTLAND RAILROAD.—A company has been formed to build a railway, which shall establish direct railway communication with Portland and Ogdensburg, which is situated at the head of lake navigation.

THE GIFFARD INJECTOR.

THE Giffard Injector, as all know, is an instrument in which a jet of steam coming out of a boiler, and being condensed by a stream of water, surrounding and mingling with it, imparts to that water such force or velocity that it is able to enter the water space of the same boiler, notwithstanding the resistance of its internal pressure.

In its simplest form, it consists of the following parts, shown in the accompanying cut. A nozzle, A, by which steam is admitted in the axis of the apparatus; around this an annular space by which water from B, flows in around the steam, and mingling with and con-

Fig. 1.



densing it in the conical tube, D, is driven through the pipe, H, and valve, I, into the boiler. Excess of steam or water from want of adjustment escaping by the outlet, F F, and G.*

The action of this instrument seems at first sight, to be discordant with certain principles which are, with good reason, accepted as absolutely certain; and for this cause the mind in grasping the idea of its operation, is disturbed by a sense of this discord, and the difficulty of a clear comprehension, is thus enhanced.

We may therefore well begin our general description by showing how this apparent discord comes simply from a neglect, or omission from our view, of certain important conditions.

At the outset, then, the idea that a jet of steam escaping from a boiler, should be able to enter the same boiler again, carrying with it an added quantity of water, seems to be in direct opposition to the general maxim, that the amount of a force can in no way be increased by the intervention of any sort of machinery.

The following consideration, however, will to some extent, at least, relieve this difficulty. If we suppose the reservoir of steam in the boiler to receive no addition of force or supply during the experiment, it is clear that its elastic force or effective pressure, will

* This cut shows simply the principle of the instrument, all details of construction being intentionally omitted.

be reduced in proportion to the volume of steam withdrawn. Thus if half its contents are removed, the pressure, exerted by what remains, will be reduced to half. On the other hand, if water, even at the full temperature of that in the boiler, is introduced, it will only increase the pressure in proportion to its volume. To restore the pressure of the boiler, diminished by withdrawing half its capacity of steam, the same amount, or half its capacity of hot water must be forced in. Now, in the case of the injector, we know that nothing like this occurs. The steam escapes *as steam*, and is returned *as water*, with a volume reduced say 1000 times, and even if it carries with it twenty times its volume or weight of fresh water, there would still be a loss of pressure or effective force in the boiler, fully equivalent to the work performed in introducing the supply.

The force implied in expelling the steam, and therefore lost by the boiler, would thus clearly be a greater one than that restored by the introduction of the water.

We have, as it were, a rod or cylinder of steam, say 1000 feet long, expelled with a given force or pressure from the boiler, and then by concentrating the force involved in this moving mass, we introduce against the same pressure a rod or cylinder of water, say twenty feet in length.

Clearly, this does not imply any self production or increase of force, but simply the concentration of an extended or diffused power, into a condensed effect. As when a ship is pushed through the water by the action of the wind upon her sails, or a heavy weight is raised a short distance through the intervention of any mechanical power, by the descent of a light weight through a great space. In short, steam pressure being well up in a boiler, if we damped the fire and started the injector, we should soon run down the pressure to a point so low, as to stop the action of the instrument, and this quite independently of the lower temperature of the injected water.

So far for the general abstract principle, and the facts that show us how entirely this apparatus is clear of all relationship to perpetual motion, or self generating force. We will next consider more in detail the special mode of action exhibited in this instrument.

The first point to be apprehended, is the difference between motion and pressure. Pressure is an isolated unit of force; motion, expressed by velocity, is the sum of many of these units.

Where a pressure exists without motion, some force, instant by instant, is in action, but each instant its previous effort is counter-

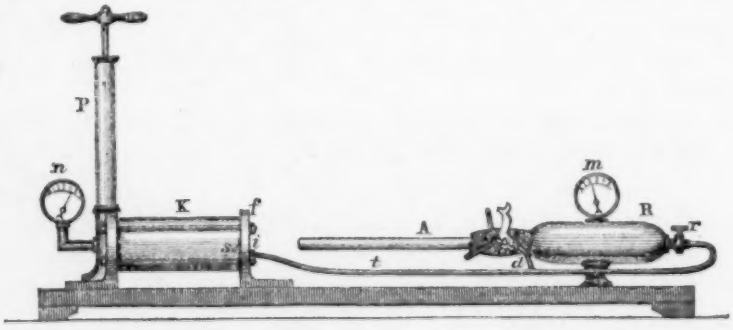
acted and destroyed, by whatever obstacle or resistance prevents motion from taking place, and keeps up the state of *mere pressure*. Thus, no more power is at any time present in the bodies concerned, than that unit or single element evolved by the force in a single instant.

When, however, the resistance is wholly or in part removed, then the force produces a certain amount of motion in the body affected, during the first instant, to which it adds in the second and third and so on; the force thus being transformed into motion, and accumulated in that form in the moving body, so developing a constantly increasing velocity, proportional to the time of action or number of force-units involved.

This principle undoubtedly is concerned in the operation of the injector. The escaping steam acquired a high velocity, which is in no respect reduced by its condensation into water, and only diminished (in proportion to the additional amount of matter set in motion) by the added quantity of water which it takes up and carries with it against the valve, it is thus easily able to open that valve and introduce the water against the mere *pressure* of the boiler.

This principle is very happily illustrated in the apparatus devised by M. E. Bourdon, and constructed by Salleron (as we see from his catalogue), and which is designed to illustrate the relations which exist between velocity and pressure, in solid as well as in fluid bodies.

There is, in this case, arranged a glass reservoir, K, into which air is forced by means of a condensing pump, P, while a gauge, *n*, denotes the amount of pressure thus developed.



In one end of this reservoir is a valve, *s*, opening inwards, and immediately opposite to it an air-gun provided with a reservoir, R,

which receives its charge from K, by the tube, *t*, and therefore will have exactly the same pressure. Having charged both reservoirs, we then close the stop-cock, *r*, and discharging a ball from the air-gun, it will open the valve, *s*, and enter K, against a pressure fully equal to that which developed its own motion. From what we have said before, the reason of this is clear.

The velocity of the ball expresses the sum of all the forces exerted by the air upon it, during the many instants it occupied in passing out of the barrel of the gun; the resistance of the valve is simply the single force of the air pressure, exerted for the instant required to open it.

Again, we may consider the action in another and quite different light. Let us suppose that the steam is issuing with the full velocity due to the pressure, from an orifice of one inch in area. In the nozzle of the injector it is condensed into water, without, however, suffering any change in its velocity from this cause, its bulk will by this means be reduced, say, 1000 times, and therefore its area of cross section (the velocity being constant), will experience a similar reduction. Neglecting loss by friction, it would then be able to enter the boiler again by an orifice $\frac{1}{1000}$th of that by which it escaped, and we should thus have the total force expended by the steam within the boiler on the area of an inch in expelling the steam jet, concentrated upon the area of $\frac{1}{1000}$th of an inch, and therefore greatly superior to the opposing pressure exerted upon that small area.

If an additional quantity of water were taken up by the jet, as in the actual case of the injector, its velocity would be diminished in an equal proportion, and the area of inlet required for its passage increased in like amount, to make up for its slower motion, and again in equal proportion by reason of the greater volume to be introduced, but we clearly have margin enough for both these deductions. Thus suppose twenty times the weight of the steam added to it in fresh water, thus reducing its velocity to $\frac{1}{20}$th, and demanding an area of inlet increase twenty times to allow for this slower motion, and twenty times again for increased material, in place of 1000 to 1, we should have the areas of escape and entrance, or the power and resistance as 1000 to 20×20, or 400, or as $2\frac{1}{2}$ to 1, which shows an abundant margin for loss by friction, &c.

It may occur to some, that this reasoning looks like a contradiction to the doctrine of hydrostatic equilibrium between large and

small connected vessels, but a little thought will show where the distinction lies.

In a large and small vessel, the change of diameter in the different parts of the fluid, is accomplished by the resistance of the sides of the vessel, and thus if the area is contracted, so also is the actuating force opposed and counteracted; but in this present case, the contraction of the jet is the result of no pressure externally applied, but of the internal, inter-molecular contraction of the moving particles in condensing, which can therefore have no effect upon their actuating force, general motion or velocity. We are therefore fully warranted in assuming, that the contraction of the jet by condensation, is accompanied by a concentration of its moving force.

In this, as in all other modes of explaining the action of this instrument, we are brought back to the condensation of the steam in the nozzle, D, as the true cause of the development of power and of the effect produced. It will therefore be readily apprehended that if, by reason of a high temperature in the feed water, no condensation took place, the instrument could not work; while a temperature short of this, would diminish proportionally the amount of water thrown. Such, exactly, is the fact observed in practice.

(To be continued.)

COAL AND FIRE-CLAY MINES have recently been opened in Warren County, at the forks of the Alleghany and Kinsua. The coal mines lie twelve miles up the Alleghany River from Warren, and thirty-six miles from Olean, in New York State, a point on the New York and Erie Railroad, and terminus of the Genesee Valley Canal. The *Titusville Herald* says: "The explorations already made have discovered the fact that the bed of cannel coal in this mine is four feet in thickness, the bed of fire-clay below it seven feet in thickness, and still beneath this, a bed of bituminous coal four feet thick, which will make a drift in the mine of fifteen feet. The quality of the fire-clay is very superior, equal to that of the Pittsburg region; while the coal is pronounced by competent judges, equal to the English cannel brought to the New York market. The proximity of this coal field to the projected railroad from Warren to the Erie road, adds to the marketable value."

COPERNICUS BY EARTHLIGHT.

EDUCATIONAL

SUNLIGHT AND MOONLIGHT.

A Lecture delivered at the Academy of Music, before the Franklin Institute, on May 23d and June 6th, 1868.

BY PROF. HENRY MORTON, PH.D

(NOTE.)—The following report of this lecture has been prepared at the request of members of the Institute, and with the view of placing in an accessible form much matter of general interest in connection with the wonderful developments of modern astronomical research (especially those relating to photography and the spectroscope), which are either quite inaccessible to the public at large, or only to be reached with great labor and cost. In pursuance of this plan, arrangements have been made for the introduction of an entirely new and most valuable series of illustrations, including fac-similes of the admirable photographs of the moon, made by Prof. Henry Draper, M. D., and Mr. L. A. Rutherfurd, the star spectra, studied and mapped by Prof. W. A. Miller and Mr. William Huggins; views of sun spots by F. Howlett, and views of the planets by Mr. W. Lassell, Mr. J. N. Lockyer and others.

PHONOGRAPHIC REPORT.

The moon, as we all know, shines by reflecting light, the source of which is in the sun. For various reasons, among which it must be acknowledged the convenience of our scenic arrangements holds a prominent place, we will consider this reflected light and its secondary origin in the first instance, and then follow it back to its fountain and source. This order, however, is not unnatural, and might have been selected even if not suggested by the conditions above mentioned.

Moonlight, then, being reflected light, we will first consider some of the general laws of reflection. At the very outset, however, we must notice that there are two sorts of reflection, one known as regular or as specular reflection, which follows very rigid and precise rules, the other diffused or irregular reflection, which is emancipated from these restraints, but has its own special conditions and modes of action.

When rays of light fall upon smooth or polished surfaces, they are in part repelled or thrown off again in such a manner, that the angles made by the approaching and receding rays with the surface

or its normal (*i. e.* line perpendicular to the surface), are equal. This is illustrated by the accompanying cut.

We have here a vertical graduated circle, on which degrees are marked and numbered right and left from the point M. At the centre is a little horizontal mirror. By means of the adjustable mirror, M, a ray of sunlight is caused to pass through the small opening, N, beneath it, and to fall upon the central mirror, its angle with the normal to that reflecting surface being N*n*A. If now we move the small screen P to such a point that the angle P*n*N is equal to N*n*A, then the reflected ray will strike it, and make a bright spot at its centre.

If, however, light falls upon an irregular or unpolished surface, it is in part reflected, not in any one, but in every direction, and this not from any inversion or abrogation of the other law, but simply from a new condition of its action, as the surface in this case consists of an indefinite number of minute surfaces at every imaginable angle to the incident rays which therefore *ought* to be scattered in every direction, according to the first law.

Yet this difference is a marked and striking one, and deserves our notice and consideration. It is by reason of this difference that a sheet of paper looks bright, no matter how the light falls upon it, while a polished plate of silver or a mirror will seem black unless in a certain position with reference to our eyes and the source of light.

To make this difference clear, and to give impressiveness to the fact, I have arranged some experiments which I will first exhibit to you, and afterwards explain, that you may first enjoy the pleasure of a mystery and a surprise, and then the greater delight of investigation and acquired knowledge as to cause and effect.

You have, of course, observed behind me, this large mirror (for which we have to thank the kindness of Mr. Earle, in whose establishment it was produced), and which has been presenting to you another vast audience, vibrating with the flutter of fans and bright with fair faces. I bring this lighted candle near it, and you see the twin image of its tiny flame, proving if proof be needed, that what is before you is a veritable and vast reflecting surface.

Now I tell you, that there is beside upon that mirror a beautiful fairy or phantom form, invisible to you, equally invisible to me, but able to reveal itself, if we but grant to its bashfulness, or to the magic spell of optical laws to which it is subject, the protection of this delicate white veil, which, as you see, is itself void of any marking or irregularity in its filmy surface. My friend, Mr. Moody, will now place himself on the platform behind the mirror, and will then drop the veil over the surface of the glass.

(A thin veil of bobinet with a rich fringe, and attached to a light rod by means of which it could be pressed close to the surface of the glass within the frame, was here let fall over the mirror, when at once a beautiful figure of Ariel appeared as if on the veil.)

Instantly the Phantom of the mirror and veil, the Spirit of reflected light, appears in delicate beauty. The veil is now wrapped together and drawn off to one side, seeming to enfold and shroud the Spirit within, and both fall together to the floor, from which I now raise the veil, empty of its celestial visitant, as at first.

Let us now look for an explanation of these results. That little box with its brazen nose, is the "magic lantern," or "Aladdin's lamp," to which this spirit owes obedience.

Shut up within its thin walls, has been burning since the curtain rose, a brilliant lime light, whose rays, collected and guided by various lenses, have been all along and are now projecting a fairy-like image upon the surface of the mirror, but the rays which form this image, coming obliquely from one side, are thrown off obliquely toward the other, and are lost behind the side scenes.

When the veil descends over the glass, it offers a surface capable of irregular reflection, and the rays no longer following a single path, are scattered in all directions, so that some from each point reach the eyes of every one, no matter where he may be placed in the house.

We will now change the arrangement of the mirror somewhat, so that the reflected rays will no longer fall behind the scenes, but upon this transparent screen, which is supported close to the edge of the stage on the opposite side to that occupied by the lantern. You then see the phantom figure, on a larger scale, clearly depicted on this screen, while yet as before, no sign of an image is visible on the mirror, although as you know, it is only by way of, and through reflection from, this mirror that any image reaches the

screen at all. If a small screen of white paper is held over part of the mirror, an image is clearly seen upon it, while the corresponding portions of the figure disappear from the transparent screen in front.

We now remove the picture from the lantern, and allow a broad sheet of light to fall upon the mirror, and to be reflected to the transparent screen, brightly illuminating it.

I now breathe upon the mirror, and at once you see a bright spot on the glass, and a dark one on the screen. The fine particles of moisture give an irregular surface on the glass, which scatters the light in all directions, so that some of it enters the eyes of each one, but for that very reason but little goes to the screen.

Again, I take this little steam atomizer, which is projecting a misty spray of water, and with its jet as a brush, trace on the surface of the mirror, characters which *there* seem drawn with fire, but on the screen appear painted with ink.

This, then, illustrates the difference between regular and scattering or diffusive reflection. To the first we owe those beautiful effects of duplicated images we see in still water, presenting an inverted image of every object in its vicinity, as well as the countless uses and applications to which mirrors and polished surfaces are applied.

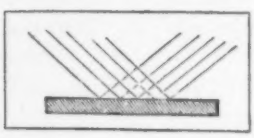
To the second, we owe the visibility of all ordinary objects which are seen by the scattered light they reflect, and among which the moon is to be classed in this relation. Of these various effects, I now bring before you many beautiful illustrations in the pictures which are being projected on the huge screen, forty feet square, which, while I have been speaking, has silently descended just behind me, and on which, Mr. O. H. Willard, well known to many of you for his skill as a photographer, is projecting from a large lantern, 90 feet back at the rear of the stage, various admirable photographs of his own production, prepared specially for their present use, and representing, as you see, landscapes with still water, in which the shrubs, and trees, and buildings on the banks, find themselves reflected, and pictures in which groups of statuary and other objects are combined with mirrors, in such a way as to illustrate the various points to which we have alluded.* (A number of pic-

* The lantern used on this occasion was the large one made by Mr. J. Zentmayer, and described in this *Journal* at page 280, Vol. LIV., having a triple lens condenser eight inches in diameter, and supplied with photographic glass pictures of a corresponding size. With a large jet, burning about four cubic feet an hour of each gas, this lantern covers the immense screen of 1600 square feet, in a most satisfactory manner.

tures were here exhibited and described, which it would be impossible for us to reproduce in this place without an outlay incommensurate with their actual importance, we must therefore leave to the reader's memory of actual scenes and his imagination, the details of this subject.)

Before leaving this department of our subject, we may well devote a little time to the more full expression of the results flowing directly from the law of regularly reflected light already stated. In consequence of the equality between the angles of incident and reflected rays, it follows that the mutual relations of a group or sheaf of rays will not be changed by reflection, though their common direction will be altered. Parallel rays will remain parallel, and diverging rays will diverge exactly as before. This is shown by figures 2 and 3, which explain themselves.

Moreover, we see that if diverging rays are reflected by a plain surface, their paths after this action will be exactly such as they would have followed had they come from a point exactly as far *behind* the reflecting surface, as



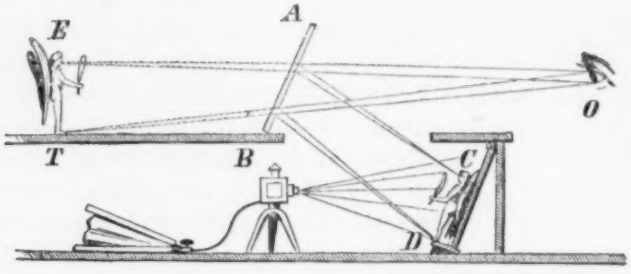
their real origin is in front of it, and in a like relative position. This is shown in Fig. 3, where the rays from A, after reflection, pass off exactly in the same paths they would have followed if emanating from B. An eye placed at C would, therefore, receive them exactly as if they had come from B, and if unaware of the reflecting surface, would believe them so to originate.

It is thus that all objects seen in a mirror appear to be behind its surface, and would actually deceive us, did we not, from experience, correct the impression.

Advantage is taken of this in many ingenious optical deceptions, which have been devised of late years, such as the Ghost, invented by Dr. Pepper, of London, the Floating Head, the Sphinx and the Proteus. I do not attempt to show you any of these, because the existing conditions of size and arrangement in this house, unfit it for such a purpose. But I will briefly describe one of them, which will illustrate the facts just mentioned, and the principle involved in all these devices.

The Ghost is thus arranged. A large sheet of unsilvered plate glass is placed across the stage, near the front, as at AB., care being

taken, by disposal of architectural ornaments at its ends and arrangements of light, to conceal its existence from the audience. A figure or person robed to represent the ghost or spirit, is placed at CD, beneath the stage, and brilliantly illuminated with a lime light.



The rays of diffused light from this figure, passing through the trap-door above it, are reflected from the glass into the eyes of the audience at O, precisely as if they came from an object situated at ET, and the presence of the reflector being unknown, the deception is very perfect.

The various points above noticed show us that the kind of reflection by reason of which the moon shines, is diffused, and not regular, for if the moon were a polished ball, she would shine but as a single point or star of light, as does any smaller polished ball or bead; and even if (disregarding all astronomical fact) we assumed the moon to be a vast flat polished disk, it could only then show us an image of the sun, which would be entirely lost by a very slight change in our relative positions.

The moon, then, must possess an irregular surface, which scatters the light rays of the sun falling upon it, in all directions, so that we receive some of them whenever we are anywhere within sight of her illuminated face. Like the light similarly reflected from other familiar objects, this will, therefore, by its changes, differences, and irregularities, reveal to us the character of the body by which it is thrown off, and in this way we shall now use it in a study of the moon's topography, structure and scenery.*

* The frontispiece of this article, representing the Lunar Volcano, Copernicus, and its vicinity, as seen by earth light, which will be more fully mentioned in future, is engraved from one of the admirable drawings made by Mr. James Hamilton, to illustrate this lecture by the use of photographs taken from them, and projected on the screen.

(To be continued.)

CHEMICAL EXPERIMENTS FOR THE LECTURE-TABLE.

By Prof. Albert R. Leeds.

(Concluded from page 420.)

Ignition of Sulphur and Phosphorus in an atmosphere of Oxygen.—Through the cork of the apparatus, figured on page 319 of the second American edition of Graham's Elements of Inorganic Chemistry, to illustrate the continued manufacture of phosphoric acid, and which may likewise serve for the formation of sulphurous acid by direct combustion, two copper wires are passed at diametrically opposite points. The lower ends of these copper wires are connected by fine platinum wire, three-quarters of an inch in length. The wires are then forced down into the bottom of the porcelain crucible, and the platinum covered with pieces of phosphorus or sulphur. The outer ends of the copper wires are connected with the poles of a galvanic battery, consisting of two Bunsen cells. The brilliant flash of light which ensues upon making a connection with the battery, standing perhaps many feet off, is of a striking description. An attempt was made to start the combustion of iron wire in oxygen, in a similar manner, by connecting the ends of two iron wires by a piece of platinum wire, a quarter of an inch in length; but, although the connecting wire became incandescent, the iron did not ignite. It may be that a stout piece of platinum and a large battery would succeed, but the employment of a greater number of cells than two was not thought worth while.

New forms of Aspirators.—On page 49, July number, 1867, of the *Journal of the Franklin Institute* will be found a drawing of a large glass tank for exhibition of chemical experiments. One of the two lateral reservoirs figured in the engraving, will be found a very convenient aspirator for drawing oxygen through the globe spoken of above, as being employed to illustrate the continued manufacture of phosphoric acid, or for similar experiments. The construction of the aspirator is as follows: Close to the bottom of a japanned tin pail, which is ten inches in depth and eight inches in diameter, a brass stop-cock is fastened and allows the water to run off into a bucket placed on the floor. The tube of the stop-cock, which is somewhat longer than usual, has a short, vertical tube fastened into its upper surface, in front of the stop-cock. This vertical tube is connected by means of an India-rubber tube, with the

wash bottle or other vessel, through which air is to be drawn. On partially opening the cock, the deficiency of water in the pipe leading to the bucket is supplied by a continued current of air drawn in through the vertical tube.

A still simpler contrivance, when there is, as there should be, a hydrant-cock at the back of the lecture-table, is to attach a two-way tube, made in the form of a Y, to the hydrant. The wide upward arm carries off the stream of water, and the air is drawn in a rapid current through the narrow arm.

The gasometer, which is figured and explained in another part of this number of the *Journal*, serves also as an aspirator for small but regular amounts of gas, and has the further advantage that no water besides that which is contained in the apparatus is required.

Cell for exhibiting Electrolysis upon the Screen.—A glass tank, similar to that above mentioned, as described by Prof. Morton, in the October number, page 281 of the *Journal*, may be employed for the following experiments also. The two upper clamps, however, contain in addition a screw passed through the end faces of the front corners of the clamps, as seen in the drawing, and serve for the adjustment and fixing of the two copper wires which form the poles of the battery. These wires are connected below the two upper clamps by means of binding-screws with the battery, and rising to the height of two or more inches above the cell, curve downward so as to form an inverted U, and terminate in strips of platinum foil the one-eighth of an inch wide, and two inches in length. The electrodes are separated by a thin partition of India-rubber, which terminates about the three-eighths of an inch above the bottom of the cell, and thus allows a free passage to the galvanic current, without any admixture at the same time of the anion and cathion. It is best to make the tank quite small—three inches square is sufficient—and to employ an inverting prism in the lantern used to project the decompositions on the screen. In this way, the audience will obtain a clear idea of what otherwise appears from its complicated look as seen upon the screen, quite difficult of comprehension. When a dilute solution of potassic iodide and starch is introduced in the tank, and a connection is made with the battery, a dark blue cloud at once encircles the electro-positive pole. Every time the connection is made or broken, the slight jar imparted to the electrode sends off a fresh wavelet of starch iodide into the sur-

rounding colorless fluid, until finally, one-half of the screen becomes invisible, the other half remaining cloudless. On reversing the electrodes, the whole tank becomes opaque.

When the tank contains a neutral solution of potassic or sodic sulphate, the change of a solution of litmus from purple to red at the anode, or of one of violets or red cabbage to red at the anode, and green at the cathode, or of cochineal to yellow at the anode, and purple at the cathode, may be shown. The last experiment is not very satisfactory, on account of the slight alteration of tint.

If the electrolytic cell contains brine, the bleaching action of the chlorine, which is liberated at the electro-positive pole, upon litmus, ink, magenta, cochineal, &c., may be shown. It seems very singular, that while an ink (the one employed was made of logwood and bichromate of potash) may be bleached to such an extent as to allow the light to pass freely through the electro-positive side of the decomposing cell, a deeply colored solution of litmus will not, and this too though the electro-negative side of the tank, to one looking directly at it, appears purple, and the electro-positive side colorless. The reason is to be found in the great number of particles of bleached organic matter which float about in the liquid, and render it turbid. A similar difficulty is encountered from the opacity produced by the froth, which is formed by the escaping bubbles of gas.

Improvement in the Construction of the Magic Lantern.—On page 132, August number, 1867, of the *Journal*, will be found a drawing of the Magic Lantern, in the greatly improved form employed by Prof. Morton, and on page 133 a description of the apparatus for carrying the lenses, as follows: "The lenses, &c., may be attached by means of brass tubes, to the cell of this condenser; but where it is desired to adapt the lantern to a great variety of uses, such as will be described in these papers, it is far better, or rather essential, to have a separate support for the objectives, with a free space for insertion, arrangement and removal of 'objects' between. For this purpose, the most convenient and 'flexible' (we use the word in a figurative, not literal sense) arrangement, is that shown in the cut. A flat strip of black walnut, mahogany, or cherry, is attached to the front of the box, as shown at E L, and upon it slides an upright frame, M N, into the grooves of which drop pieces provided with rings like I, fitting the various instruments to be employed." I

have somewhat modified the above construction, and I believe that Prof. Morton thinks to advantage, by fastening the upright, which carries the cells for the lenses, permanently to the flat strip of wood, and making the latter slide in and out to the extent of twelve inches, between wooden grooves cleeted to the bottom of the lantern box. This gives such firmness to the lantern, that it is independent of the table upon which it is placed for support, and it may be tilted at every angle without any fear of displacement of parts from the weight of the brass cell of the objectives, &c. When not in use, the lenses may be pushed back against the front of the lantern, so as to occupy the least possible space, and when required they may be drawn at once into position.

Drafting and Writing upon the Screen.—It is often desirable to write out chemical formulæ, or to perform some simple numerical calculation, or to make a diagram of some apparatus, before an audience in a large room. This, which would be difficult of accomplishment by ordinary methods, may be satisfactorily performed in the following manner. A sheet of clean glass, or what is more striking in appearance, a plate covered with an opaque film of blackened collodion, is placed in front of the condenser, and then the writing or drawing is executed upon it; in the former case, with India-ink, in the latter, with a sharp point. An inverting prism placed in front of the objective brings the writing into its natural position with respect to top and bottom, and the inversion of the picture with respect to right to left, instead of being in this case a disadvantage, effects the very object in view. For the writing which is executed by the lecturer while facing his audience, is itself inverted with respect to a lantern facing in an opposite direction.

Transpiration of Gases.—On page 14, of *The Student's Practical Chemistry*, will be found a description of the apparatus which is usually employed to illustrate the transpiration of gases through porous partitions. If, instead of employing a straight glass tube to dip down into the vessel filled with colored liquid, one is employed which has been bent into three or more spirals at different parts of its course, so as to cause the liquid to run round upon itself many times in its upward course through the tube, the experiment takes a much more pleasing and striking appearance.

Franklin Institute.

Proceedings of the Stated Monthly Meeting, May 30th, 1868.

THE meeting was called to order, with the President, Mr. J. Vaughan Merrick, in the chair.

The minutes of the last meeting were read and approved.

The Actuary submitted the minutes of the Board of Managers, and reported the donations to the library received at their stated meeting, held May 13th inst., from the Royal Astronomical Society, the Chemical Society, the Society of Arts, and William Leighton Jordan, F. R. G. S., London; l'Academie des Sciences, la Société d'Encouragement pour l'Industrie Nationale, Paris, la Société Industrielle, Mulhouse, France; der K. K. Geologischen Reichsanstalt, Vienna, Austria; Major L. A. Huguet-Latour, Montreal, Canada; Commodore B. F. Sands, Superintendent U. S. Naval Observatory, Washington, D. C.; James B. Francis, Esq., Lowell, C. L. McAlpine, Esq., C. E., Stockbridge, and E. H. Derby, Esq., Boston, Mass.; Young Men's Association, Buffalo, N. Y.; John Alexander Ferris, Esq., San Francisco, California; and George E. Chambers, Esq., Registrar of Board of Health of Philadelphia.

The various Standing Committees reported their minutes.

A paper upon "Pneumatic Bridge Foundations," by Mr. O. Chanute, was read by the Secretary.

The Secretary's Report on Novelties in Science and the Mechanic Arts was then read.

After which, on motion, the meeting adjourned.

HENRY MORTON, *Secretary.*

Bibliographical Notices.

Catalogue of Philosophical Apparatus. E. S. Ritchie & Sons. Boston, 1868.

We have just received the above, which is a new edition of Mr. Ritchie's well known illustrated Catalogue, which, as many of our readers know, is the most extensive and best executed work of the kind ever produced in this country.

The present edition is worthy of special note, by reasons of several additions which have been made, and certain alterations introduced to keep pace with late discoveries, and inventions in the direction of physics.

A few of these novelties we will here notice. Thus, on p. 4, is shown a very neat and compact arrangement for the illustration of pulleys, the capstan, &c., possessing many advantages over that heretofore in use. On p. 11, an exceedingly well arranged and substantial hydraulic press. On pages 13 and 15, is figured (entire and in detail), Mr. Ritchie's new air-pump, described in this *Journal*, p. 13, of the present number. On p. 21, is shown Edson's Hygrodeik, fully described in this *Journal*, Vol. LV., p. 67. On p. 26, an improved form of Natterer's apparatus for liquefying gases. On p. 27, Mr. Ritchie's improved form of the Holtz Machine, described in this *Journal*, Vol. LIII., p. 344. On p. 34, Mr. Ritchie's Liquid Compass, fully described in this *Journal*, Vol. LV., p. 218. On p. 41, a large number of Geissler's Tubes, which Mr. Ritchie is the first to manufacture in this country, and thus puts within reach of all, these most beautiful of modern instruments, without the risks and annoyances attending importation. On p. 42, we find Prof. Lyman's apparatus for the illustration of wave motions, a full account of which will be published in our next issue. On p. 48, we find various new apparatus devised by Kœnig, to illustrate musical vibrations by means of the images of flames (controlled by the vibrating body), in revolving mirrors. On p. 54, account is given of magic lanterns, with many of the accessories described in various papers on this subject, which we have published during the last year. There are, beside these, other novelties, which our space is too curtailed to notice, and the entire catalogue will be of great value to all concerned with physical researches or demonstrations.

We have received from J. B. Lippincott & Co., and will notice in our next issue, *The Mechanics' Tool-Book*. By W. B. Harrison. And *The Practical Use of the Blow-Pipe*. By G. W. Plympton, A. M., both published by D. Van Nostrand, New York.

A COMPARISON *of some of the Meteorological Phenomena of* MAY, 1868, *with those of* MAY 1867, *and of the same month for* SEVENTEEN *years, at Philadelphia, Pa.* Barometer 60 feet above mean tide in the Delaware River. Latitude 39° 57½′ N.; Longitude 75° 11¼′ W. from Greenwich. By PROF. J. A. KIRKPATRICK, of the Central High School.

	May, 1868.	May, 1867.	May, for 17 years.
Thermometer—Highest—degree.....	77·00°	87·00°	90·00°
" date.....	30th.	29th.	7, '60; 23, '63.
Warmest day—mean ..	68·00	78·67	79·83
" " date.....	30th.	29th.	23d, '63.
Lowest—degree.....	40·00	36·00	35·00
" date.....	3d & 8th.	4th.	7th, '54.
Coldest day—mean	48·83	43·17	40·00
" " date	8th.	3d.	3d, '61.
Mean daily oscillation...	14·80	17·64	16·85
" " range.....	4·65	5·30	5·51
Means at 7 A. M.....	54·32	54·10	58·02
" 2 P. M.	63·50	64·92	69·06
" 9 P. M.	57·19	56·50	60·93
" for the month....	58·34	58·53	62·67
Barometer—Highest—inches.....	30·209	30·423	30·423
" date.....	12th.	4th.	4th, '67.
Greatest mean daily pressure	30·195	30·367	30.367
" " " date...	11th.	4th.	4th, '67.
Lowest—inches	29·375	28·778	28·778
" date.....	7th.	8th.	8th, '67.
Least mean daily pressure...	29·492	29·013	29·013
" " " date...	7th.	8th.	8th, '67.
Mean daily range.....	0·144	0·214	0·128
Means at 7 A. M	29·846	29·855	29·802
" 2 P. M	29·835	29·804	29·766
" 9 P. M	29·841	29·836	29·791
" for the month.....	29·841	29·832	29·786
Force of Vapor—Greatest—inches	0·592	0·625	0·771
" date	27th.	29th.	14th, '54.
Least—inches.....	·177	·139	·069
" date.....	8th.	4th.	2d, '61.
Means at 7 A. M	·338	·310	·352
" 2 P. M.....	·376	·305	·368
" 9 P. M	·379	·320	·375
" for the month...	·364	·312	·365
Relative Humidity—Greatest—per cent	97·0	96·0	100·0
" date.....	7th.	8th.	Often.
Least—per cent....	30·0	29·0	16·0
" date.....	10th.	2d.	5th, '55.
Means at 7 A. M....	78·7	71·3	71·4
" 2 P. M....	64·1	48·1	51·7
" 9 P. M....	79·7	67·5	69·0
" for the month	74·2	62·3	64·0
Clouds—Number of clear days*.....	4·	7·	9·5
" cloudy days	27·	24·	21·5
Means of sky covered at 7 A. M	80·3 per ct	62·8 per ct	60·1per ct
" " " 2 P. M	77·7	67·9	62·5
" " " 9 P. M	61·6	50·0	48·6
" " for the month	73·2	60·2	57·1
Rain—Amount—inches	6·890	7·070	5·071
No. of days on which rain fell.....	13.	12·	12·5
Prevailing Winds—Times in 1000.....	N.21°32′E.245	S 82°24′W.099	N76° 6′W. 111

* Sky one-third or less covered at the hours of observation.